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Power Generation

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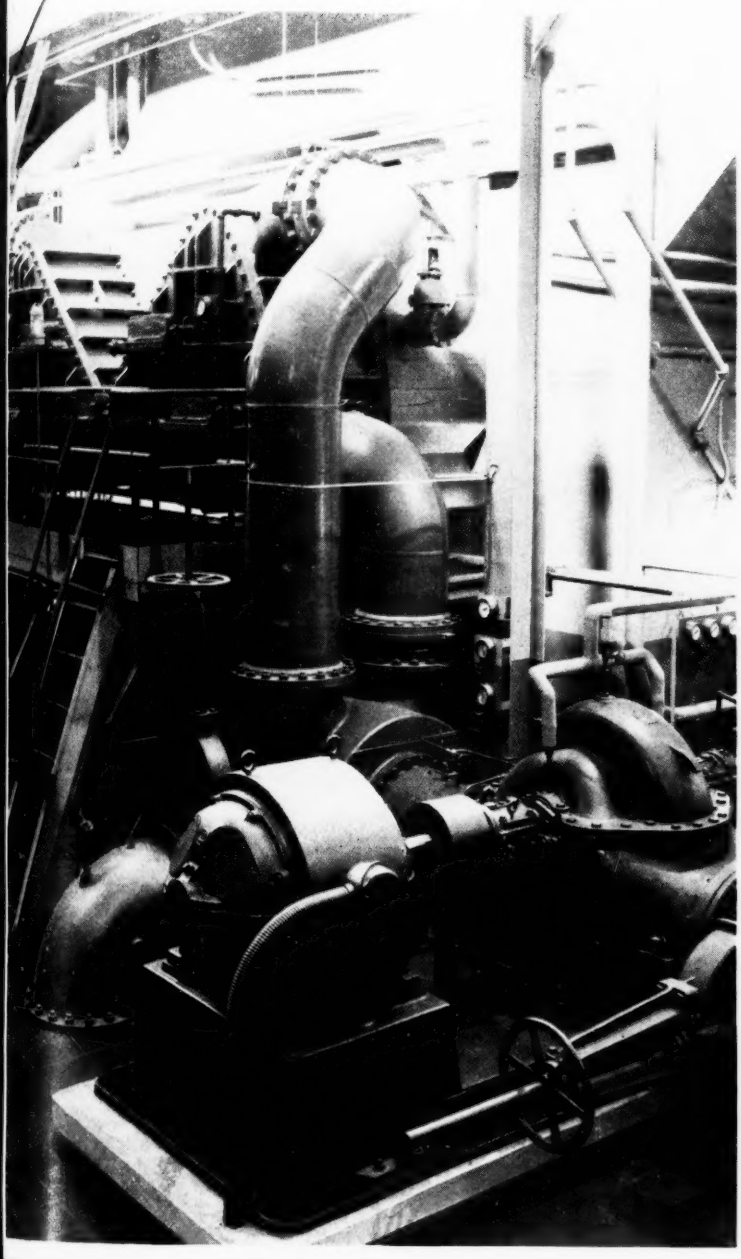

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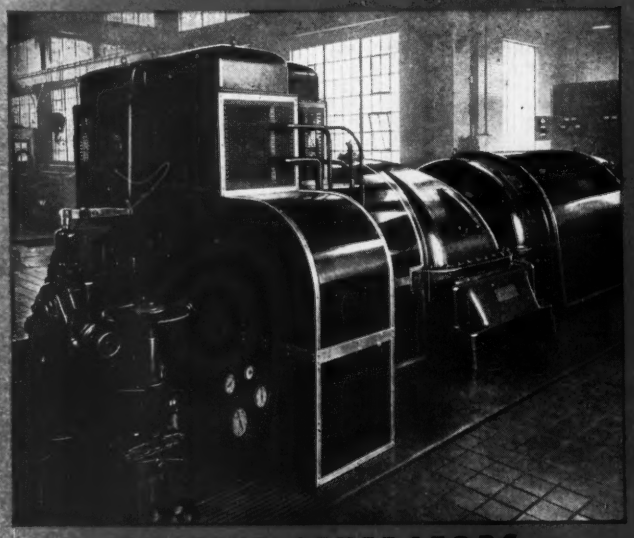
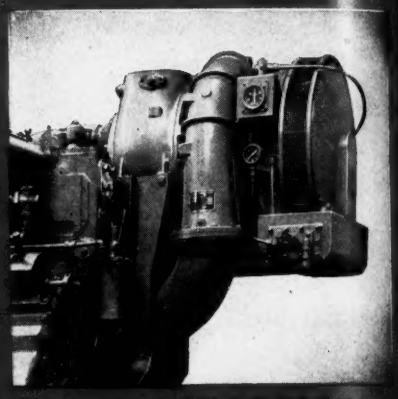
COVER: GENERAL VIEW OF CIRCULATING PUMPS, REVERSING VALVES AND TWIN CONDENSERS SERVING 30,000 KW TURBINE-GENERATOR AT THE JENNISON STATION, NEW YORK STATE ELECTRIC & GAS CORP.

he Magazine That Helps Men Responsible for Generation of Steam, Electricity and All Other Forms of Power Supply

Pacemaker fo



TURBINE GENERATORS



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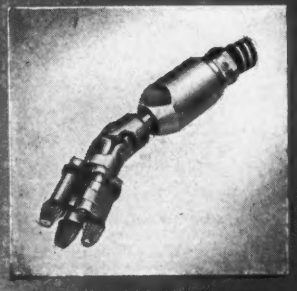

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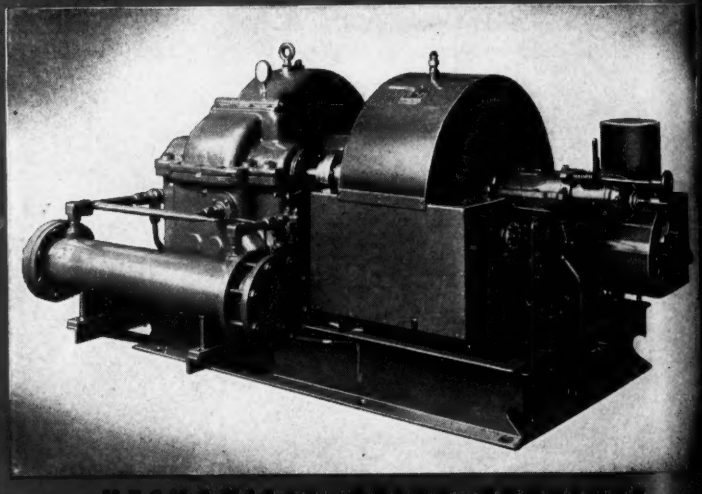

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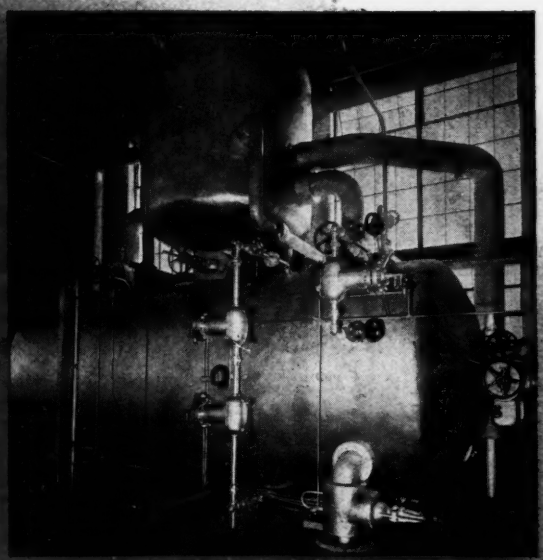
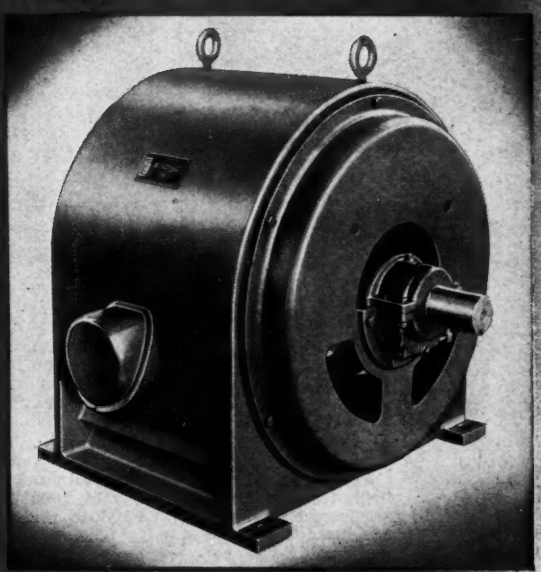
r for Progress

With the accent on "dependability", Elliott engineering has driven forward on many fronts in the past two decades, from the early pioneering in deaeration to the most recent Elliott development of the all-welded steel construction for large motors.

Engineers know they can depend upon Elliott equipment—not only upon its satisfactory performance, but also upon its outstanding operating economy. In these two basic factors, the Elliott nameplate is a symbol of assurance.



DEAERATING HEATERS



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SUBSIDIARY OF ROCKWELL MANUFACTURING CO.

EAST CHICAGO, INDIANA

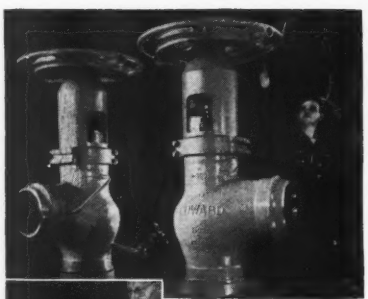
40-YEAR OLD EDWARD *blow-off* VALVES STILL IN SERVICE . . .

After 40 years these Edward blow-off valves are still in regular service and give tight closure. Edward was the original builder of steel blow-off valves.

More than 40 years ago, a railroad car builder on Chicago's far south side erected a new power plant. The blow-off valves, like the feedline and many other valves on the four boilers, were Edward.

The same blow-off valves have been in continuous service ever since and are still tight. There have been no repairs or replacements other than a few new type seats and disks.

Because the valves are subjected to frequent and sudden temperature changes and the erosive action of scale and abrasive material blown through at high velocities, blow-off service is exceptionally severe.



Edward 12 in. angle non-return valves for 1500 lb. 1000 F service. Left valve shows Equalizer running from above disk to outlet.

Internal parts of Edward pressure seal connection.

PRESSURE SEAL BONNET GAINS IN POPULARITY

For high-pressure, high temperature service the pressure seal bonnet connection continues to gain in popularity.

At the time Edward began incorporating pressure seal connections as an optional feature on the larger globe and angle stop and non-return valves, body contours were changed and internal flow passages redesigned to greatly reduce pressure drop.

Another feature, in the case of non-return and check valves was the addition of the EDWARD EQUALIZER, a piping arrangement which reduces pressure drop and helps prevent disk fluctuation in service.

Internal parts of the pressure seal bonnet connection are fairly simple but require tool-room machining care to insure a tight joint. A contingent advantage of the pressure seal connection is ease of disassembly after long time high temperature service and greatly simplified reassembly.

ON FLOWING WELLS

At St. Johns, La., are these Edward forged steel check valves, typical of many used in the oil fields.

In this case, Edward 2 in. Fig. 160 valves are on lines from 14 flowing wells at the treater and separator station. Check valves prevent back flow to wells.

Edward builds ball and piston type check valves in horizontal, angle and vertical patterns for pressures to 7500 lb. and temperatures to 1000 F. Sizes ¼ in. to 16 in.

Torque Meter Stops Bolting Guesswork

All torque wrenches in the Edward plant are regularly calibrated on torque meters, before each valve production run, to be sure that wrenches measure correctly. Valve assemblers are thus certain that correct tightening stresses are applied to threaded valve parts.

Equal stressing of stud bolts is important in proper assembly of bolted bonnet valves. Properly tightened screwed-in valve seats and bonnet bushings assure leak-proof valve trim. Evenly stressed threaded parts mean tight joints, less effect on bolting from extreme temperatures, and easier remake if a joint is ever broken.

Body-bonnet bolting on large valves is stressed to exact micrometer measurement during assembly.

EDWARD BUILDS cast and forged steel globe and angle stop, gate, non-return, blow-off, feedline stop-check, Intex (integral seat), integral bonnet Univalves, relief, hydraulic, gage valves and strainers for power, petroleum, marine, industrial and technological services.

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February, 1948

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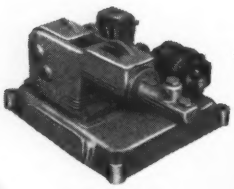
CHEMICAL TREATMENT METERING PUMPS

for Every Power Plant

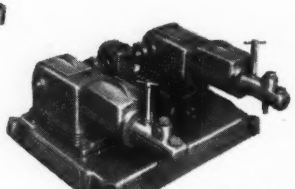
PLUNGER TYPE PUMPS FOR HIGH PRESSURES

DIAPHRAGM TYPE PUMPS FOR LOW PRESSURES

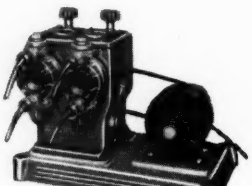
FROM THE SMALLEST JOB



Simplex



Duplex



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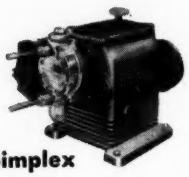
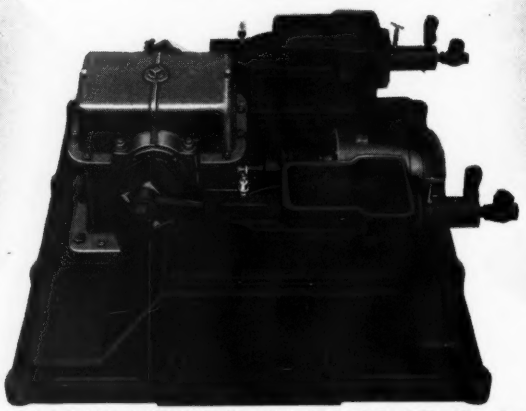


Simplex

Also available in Triplex and Quadruplex designs

Also available in Triplex and Quadruplex designs

TO THE LARGEST HIGH PRESSURE INSTALLATION



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ENGINEERS' PREVIEW

WORK is being started immediately to prepare standards which it is expected will result in better performance of disc records used on home record players and in broadcast studios, the American Standards Association announced today. The work as planned will also include magnetic recordings and sound track on film. A new committee, under the leadership of the Society of Motion Picture Engineers and the Institute of Radio Engineers, has already taken the first steps toward this end. Representatives of the radio manufacturers, the motion picture industry, broadcasting companies, and the War and Navy Departments are cooperating.

★ ★ ★

AN "EDUCATED SHOCK ABSORBER" that irons out the bumps in railroad tracks or highways has been developed by Westinghouse research engineers to provide train and bus travelers the smoothest rides in transportation history. The new stabilizer is designed to 1) eliminate more than 60 per cent of the bumps and sway caused by irregularities in tracks or roads, 2) enable trains to take curves at more than 25 per cent greater speeds, 3) bring about a 4 to 1 over all improvement in riding ease of trains and busses and 4) permit increased traffic over present rails and highways.

Floating weights that feel up-and-down and sideways motion, and a pendulum that senses the pull of centrifugal force and gravity, working together or separately, detect and respond to bumps or side-sway in just 0.003 sec. They anticipate the movement and correct it before it is felt by the train or bus passengers.

★ ★ ★

METHODS BY WHICH broad military strategy and tactics were subjected to scientific analysis are now being applied to complex civilian activities. Operations research, as the technique is called, involves an analysis of the way men and equipment act together in an organization, and is directed toward modifying the action so that the organization better attains its objective. The analysis seeks to determine quantitatively how well a given policy has been working, and what changes in policy should be made. In this endeavor, operations research is only an extension of common sense, but during the war its techniques were highly refined by a number of leading scientists attached to the armed forces.

For several years the Bell Telephone Laboratories have conducted operations research on the combined behavior of telephone subscribers, telephones, telephone operators, and switchboards, under the name of system engineering. In Great Britain several scientists active in operations research during the war have been named as advisors to the various ministries in the Government, and to such commercial enterprises as British Overseas Airways Corp., according to the *Industrial Bulletin*.

Analysis of traffic problems in greater detail than the usual type of survey, and with analytical interrelation of the statistical data, may yield worthwhile results in terms of more useful application of highway funds.

WAR'S GROTESQUE landing craft are finding peaceful jobs in the shallow waterways which have become such a part of American history and literature. Many of the vessels designed to carry troops and equipment from transports and supply ships to the beachheads have already been modified for commercial use. One type of job in which they are expected to find use is where shallow harbor or river channels prevent passage of conventional deep-draft vessels.

Ease of loading is another feature of some of these types. The special craft with bow doors, and the smaller invasion boats, may be adapted quite easily for commercial operations. Since even the largest of these vessels draw only from 3 to 6 ft at the bow and from 12 to 20 ft at the stern, their use has been proposed for Great Lakes shipping. Here draft restrictions are severe; traffic through the locks at Sault Ste. Marie is limited to a draft of about 20 ft in passing over the sills of the locks.

Screw propellers have also been adapted to use in restricted waters by fitting them in a tunnel or recess under the stern of the vessel, where the tips of the blades are above the still water line, says the *Industrial Bulletin*. A fairly recent development employs a tunnel, called the "Kort Nozzle," fitted completely around the propeller. Another new device has narrow blades hanging from a hub fitted into an underwater well at the stern of the boat, and revolving around a vertical axis. By changing the angle of the blades, the ship can be turned and reversed.

★ ★ ★

MORE HELP for development engineers, technical librarians, research workers of all kinds—a new system for finding technical information, called Zatocoding, is now being custom-designed by Zator engineers. Zatocoding is claimed to be the first and only rapid and convenient method for the finding of all kinds of technical data, information or reports stored in files of thousands of documents. It is recommended wherever conventional classification and indexing methods have broken down because they cannot handle complex specifications of subject matter, large technical vocabulary, unexpected new developments, or changing requirements for the system. In a typical custom-designed Zatocoding installation, a search such as that for all patents covering the combiantion of *Geneve movement, ratchet advancement* and *chain and sprocket drive* may be carried out in a few minutes by an untrained clerk. Zatocoding employs new principles of the mathematics of random patterns and of the logic of language in cooperation with mechanically sorted index cards. Finding proceeds from the specification of the two or more ideas that together define the wanted information. Mechanical selection presents, within minutes, the complete set of index cards relating to these ideas. There is complete freedom in the choice of the defining ideas.

Zatocoding is said to be at its best when faced with such complicated and changing information—finding problems as those presented by organic chemistry, patent literature, scientific research, or, in fact, all knowledge.

PRESENT RATE of depletion of this country's reserves of high- or medium-grade ores requires increasing use of low-grade ores for most metals and some non-metals. Because these ores cannot be used or refined directly, some of the waste must be removed near the mine by purification processes generically called "beneficiation." The term "mineral engineering" has recently been adopted by several interested groups to describe these processes, which yield a product with an increased percentage of the desired material. Beneficiation, or mineral engineering, is beginning to be necessary for Lake Superior iron ores, which are handled in tremendous volume. As it becomes more common, says the *Industrial Bulletin,* a large investment, transforming the mining region into a manufacturing area, is expected. In 1946, about 12 million tons of iron ore, or 23 per cent of the Minnesota ore shipments, consisted of concentrates from inferior ores, and it is expected that this year such shipments will approach 20 million tons. Several companies have recently announced plans to construct large-scale beneficiation plants in the Lake Superior iron ore region. The sums eventually needed for construction of such facilities in this region may well total over 500 million dollars.

★ ★ ★

"CLEVELAND, OHIO, is fast becoming a model throughout the country for a sane and workable air pollution abatement program." H. B. Lammers, Director of Engineering for the Coal Producers Committee for Smoke Abatement, reported to members of his committee this week.

"Wherever the staff of the committee goes it is asked for information concerning the setup in Cleveland," Lammers explained. "The Coal Producers Committee for Smoke Abatement takes justifiable pride in Cleveland for it was after our committee completed a survey there in October, 1946 that the Smoke Department was revamped and new rules and regulations adopted. Much credit can be given to the Air Purification Committee of Cleveland, for its cooperation and determination that something be done about the problem.

"The program has the wholehearted support of the Cleveland newspapers and stories have appeared announcing a drop of 47 per cent in the sootfall since the program was initiated only a few short months ago.

"In view of the widespread agitation for smoke abatement, it is of peculiar interest," Lammers said, "that St. Louis, which for 5 years insisted that it had eliminated its smoke, is now agitating for some of the very things which were included in the report of the Cleveland survey more than a year ago.

"In the Cleveland report the Coal Producers Committee for Smoke Abatement recommended, among other things: First, set up a committee to catalogue all types of fumes, smoke and exhaust emanating from each industry and make this a permanent record for the city, second, analyze all combustion processes particularly power plants. Smoke from these sources can be eliminated—it is very frequently due to negligence, inadequate controls and controls not functioning properly together.

"This puts smoke abatement on a sound engineering basis and when such a program is placed in the hands of a man like H. G. Dyktor, as it has in Cleveland, it cannot fail to pay dividends."

ANNOUNCING its Educational Reimbursement Program, The Carborundum Company of Niagara Falls, N. Y., becomes one of the prominent American industries to pioneer in a movement designed to promote the self-improvement of its employees through courses of studies after working hours. Its objective is to give financial aid and encouragement to those of its employees who are interested in obtaining added knowledge and training by taking approved courses in educational institutions of recognized standing such as schools, colleges, universities and correspondence schools. In accordance with the plan, employee students upon the satisfactory completion of his or her course of study will be reimbursed to the amount of $75.00 per semester and not more than $150.00 in a twelve-month period. These amounts are to cover all tuition and other fees in connection with the courses selected including laboratory and diploma fees but are not to be applied against the purchase of books.

★ ★ ★

AMERICAN INDUSTRY, according to estimates, is losing about $1,000,000,000 each year because of underground corrosion and its contingent losses. Such corrosion weakens structures and may cause accidents. It entails costly plant repairs or replacements. It may cause expensive commodities to leak and to damage property or persons. It may interrupt production or service and thereby reduce income or discommode customers.

These losses in different form and degree are suffered by operators of 965,000 miles of steel or iron pipe carrying water, gas or oil, 125,000 miles of lead-sheathed electric cable for communications, signals and power, 425,000 miles of steel rail track, and other metal structures buried or in contact with soil.

The figures above quoted were presented recently to the Correlating Committee on Cathodic Protection. This committee was recently organized by eight industry associations, the two nation-wide communications companies and an engineering association to promote better understanding of "cathodic protection" (See *Power Plant Engineering,* page 83, June, 1946, issue), a recently-developed technique for protecting buried metallic structures against underground corrosion. Its chairman is H. M. Anderson of Houston, Texas, vice president of Shell Pipe Line Corporation. Its secretary is F. E. Dolson, Jr., of St. Louis, Mo., chief distribution engineer of St. Louis County Water Company.

★ ★ ★

FOR DETERMINING the ash content of coal, sulphur content of oil, tetraethyl content of gasoline or the heavy metal content of glass, plus concentration of fillers and impregnating agents in wood, cloth and rubber, a new GE X-ray photometer measures ray absorption by directing an X-ray beam at a fluorescent screen. The strength of the ray, after it has passed through material under test, is transposed by the screen into visible light. Intensity of this light is then measured by photoelectric equipment and final reading is given on a dial. To estimate the amount of ash in a quantity of coal, the component chemicals that result in ash are checked for the amount of X-ray absorption and an aluminum disc which absorbs a like amount of radiation is selected. Then any sample of coal is matched against the disc.

"Which Squirrel-Cage Motor Shall I Buy?"

Open-Type? This general-purpose squirrel-cage motor meets about 9 out of every 10 application requirements; so chances are it's the design you'll select. Allis-Chalmers builds generously proportioned, rugged *open-type* squirrel-cage motors in sizes from 1 hp to the largest practical requirement.

Splash-Proof? Where operating conditions are conducive to entrance of particles or liquids into ordinary motors from either top or sides, Allis-Chalmers *splash-proof* squirrel-cage motors may be your best buy. They're designed to *exclude* top or side directed particles and liquids. Sizes 1 hp to the largest.

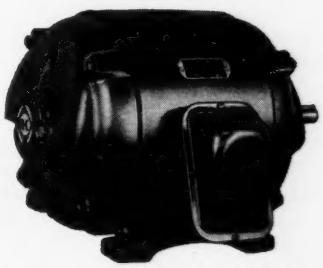
Vertical? or Flange-Type? *Either* can solve a space problem. *Vertical* motors (sizes 1 hp to largest) for vertical drives. *Flange-mounted* for side or angle drives. In both types bearings and closures are designed to prevent grease escapement. Mounting flange for attaching to your base can be provided.

Totally-Enclosed? Explosion-Proof? Completely weather-proof and fan-cooled, these motors are built to beat abrasive dust, dirt and corrosive fumes, or moisture conditions that cause windings in ordinary motors to deteriorate. *Explosion-proof type* for oil refineries, paint, varnish or lacquer plants, etc.; Underwriters approved; reduce hazards in explosive or dust atmospheres. Either type built from 1 hp and up.

Are Motor Decisions More Important Today?

YOU BET THEY ARE! One *obvious* reason is the need for keeping costs down. Another is that in the rush to fill demand much equipment is being misapplied; making it harder to maintain profits not alone today, but tomorrow, the next day and the next year—as long as misapplication continues!

That's why it's important to take a good look at motors — their characteristics — your equipment — power source and surroundings — *before* you buy and apply! If you're in doubt, don't take chances — call a motor expert! ALLIS-CHALMERS, MILWAUKEE 1, WIS. A 2327



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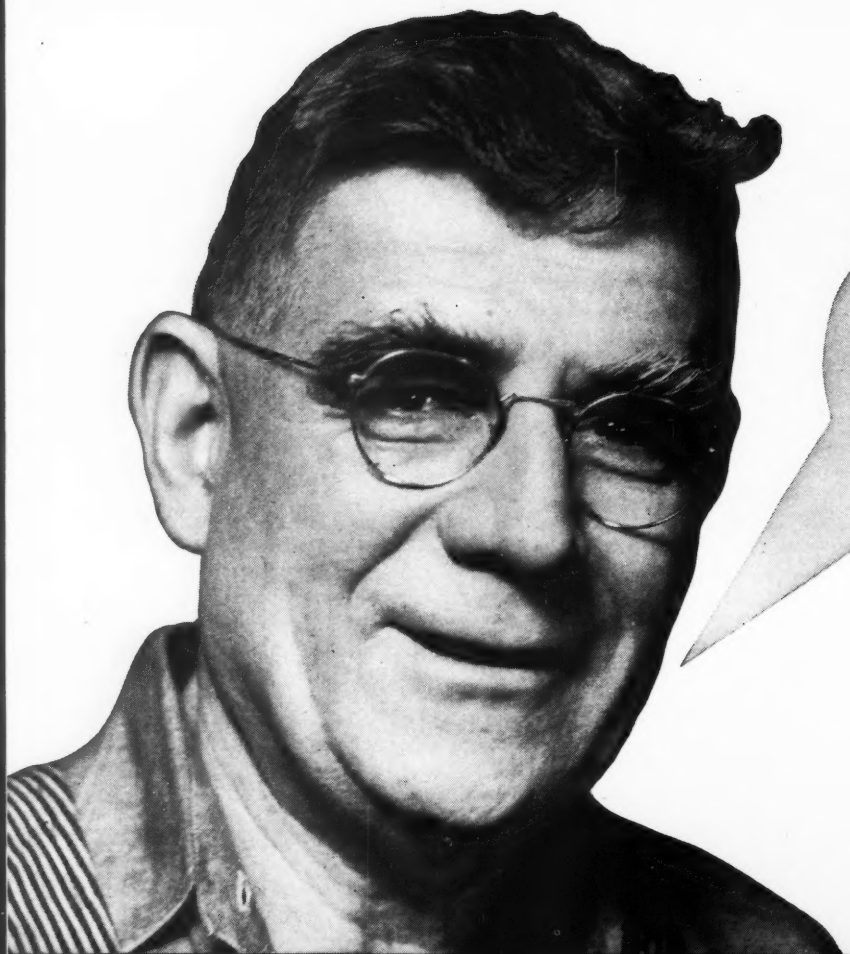
One of the Big 3 in Electric Power Equipment-
Biggest of All in Range of Industrial Products



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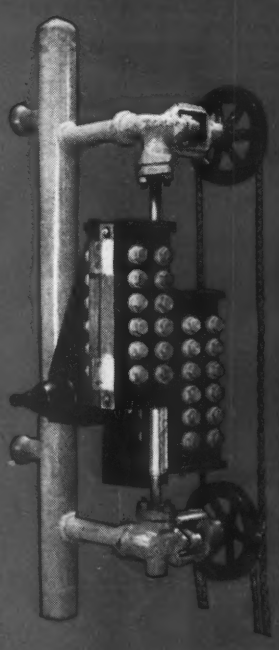
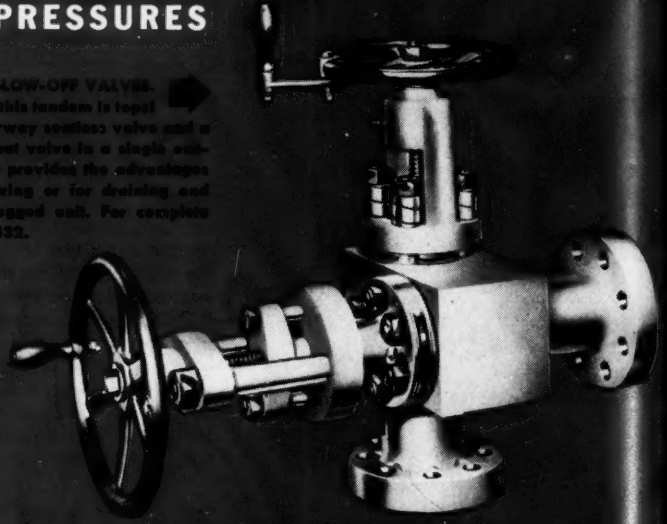


FOR HIGH PRESSURES

YARWAY UNIT TANDEM BLOW-OFF VALVES. For pressures to 2500 psi., this tandem is tops! Combining the famous Yarway seatless valve and a specially-designed hard-seat valve in a single one-piece forged steel body, it provides the advantages of both designs—for blowing or for draining and sealing—in a compact, rugged unit. For complete description see Bulletin B-432.

YARWAY HIGH PRESSURE WATER COLUMN with welded GAGE VALVES AND FLAT GLASS GAGE...for 1550 psi. Improved design gives extra strength and dependability. Flat glass gage inserts are mica protected and have spring-loaded cover-plate cap screws and pressure-sealed gaskets which prevent excessive strain on glass. Described in Bulletin WC-1811.



YARNALL-WARING COMPANY, 114 Mermaid Ave., Phila. 18, Pa.

YARWAY ST

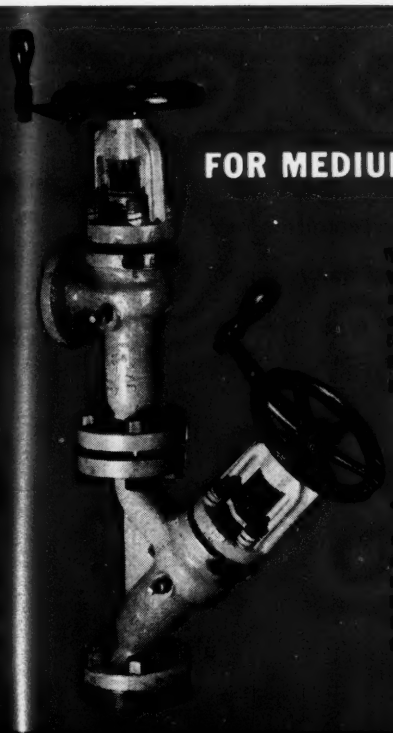
BOILER PROTECTION?
we Need it... and Get it
YARWAY BOILER TRIM"

FOR ALL PRESSURES

YARWAY REMOTE LIQUID LEVEL INDICATOR. Here's an instrument that should be used with every boiler up to 1500 psi. It brings hard-to-see overhead water gage readings right down to eye level, on the instrument panel or other convenient place. Brilliantly-lighted red and green dial gives instant, accurate boiler water level readings. Always positive because it's operated by the boiler water itself.

Indicating mechanism is never under pressure. *There are no stuffing boxes.* Action is instant, constant, and practically frictionless.

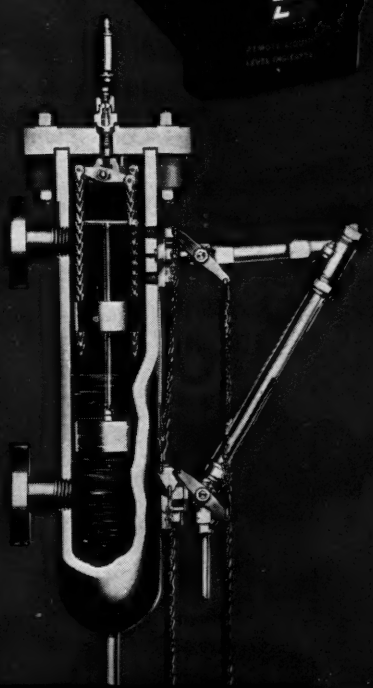
Moderate in cost . . . easy to install. Get complete description and operating details in Bulletin WG-1822.



FOR MEDIUM AND LOW PRESSURES

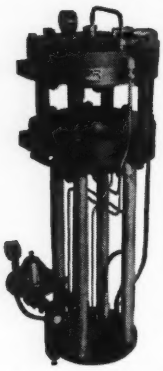
YARWAY HI-LO ALARM WATER COLUMN WITH SEGURE INCLINED GAGE. Alarm mechanism uses balanced solid weights and operates on the displacement principle to give instant, positive warning of dangerous changes from normal water level. For pressures to 600 psi. Described in Bulletin WG-1811.

YARWAY SEATLESS TANDEM BLOW-OFF VALVES. These are the valves that are standard in over 12,000 boiler plants on pressures up to 600 psi. Balanced sliding plunger type with non-clogging, straight-through flow. No seats to score, wear, or leak. See Bulletin B-434 for pressures to 600 psi; Bulletin B-432 for higher pressures.

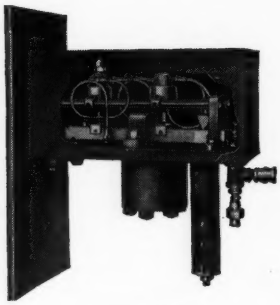


Y STEAM PLANT EQUIPMENT

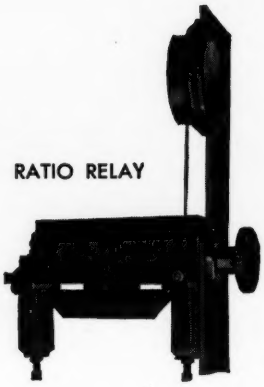
STEAM SEPARATOR



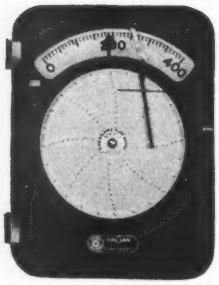
HAGAN THRUSTORQ



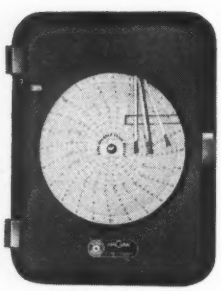
TYPE "F"
MASTER SENDER



RATIO RELAY



RING BALANCE
FLOW METER
(Indicating, Integrating
& Recording)



RING BALANCE
FLOW METER
(Integrating & Recording)

Typical applications for

This partial list, and accompanying photographs are published to remind you that Hagan service is broader than the automatic combustion control systems which are usually associated with the Hagan name.

Control of combustion rate of boilers

Constant or graduated draft control

Constant or graduated pressure control

Feeder or stoker speed control

Control of multiple fuel firing

Fan speed control

Pump speed control

Hydraulic coupling control from speed or delivery of driven unit

Constant differential pressure control (liquids or gases)

Accurate control of position from remote point

Control of steam, gas, and liquid pressures

Measurement of steam, gas and liquid pressures

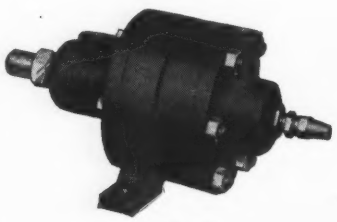
Control of pump discharge pressure and flow

Steam flow control

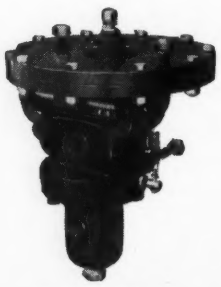
Steam pressure reduction and desuperheating control

Steam temperature control (superheat)

Removal of oil, moisture and solids from exhaust steam

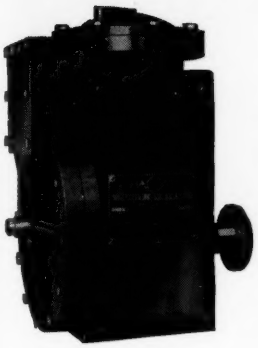


TYPE "F"
TOTALIZER

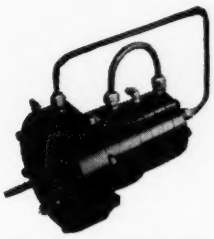


DIFFERENTIAL
TRANSFORMER

V PORT
BUTTERFLY
VALVE

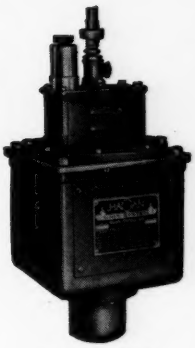


VARIABLE
RATIO REGULATOR



MICRO-POSITIONER

RECEIVING
REGULATOR



DIAPHRAGM
REGULATOR

HAGAN *equipment*

Removal of oil and moisture from compressed air

Control of separately fired superheaters

Flow control (liquids and gases)

Flow measurement of liquids and gases with pressure and temperature compensation

Gas mixing control

Fuel-air ratio control

High temperature regulation

Remote manual or automatic control

Recovery of steam from continuous blowdown systems

Program control

Oil burner control

By-pass damper control for air preheaters

Feed water heater pressure and temperature control

Liquid level control

Control of multi-speed motor drives

Safety protection for gas or pulverized coal firing

Steam jet refrigeration control

Force measurement and control

Measurement and control of thrust and torque

We will be glad to supply full information concerning any of these applications or pieces of equipment.

Hagan Corporation, Hagan Building, Pittsburgh 30, *Pa.*

THERMOSTAT

HAGAN
HALL
BUROMIN
CALGON

HAGAN CORPORATION

BOILER COMBUSTION CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
THRUSTORQ FORCE MEASURING DEVICES

Why still another big Turbine gets Nonpareil protection

Take a look at the record made by Nonpareil Turbine Oil in this large midwest utility plant.

Eight years ago Nonpareil was installed in one turbine—a 36,750 KW unit. Two years later a shift to Nonpareil was made on a second turbine—of 37,500 KW—and shortly after that on a third—another 36,750 KW unit.

Recently a new 37,500 KW turbine was put into service, and the job of lubricating it went to Nonpareil—making a total of 148,500 KW capacity which Nonpareil protects for this one utility.

What are the facts back of this record? In the six to eight years of operation on Nonpareil, neutralization numbers have stayed between .04 and .06. Losses and troubles caused by high acidity have been completely absent.

Nonpareil is the only product in its field that carries a written guarantee to last as long as your turbine without increasing in acidity above a neutralization number of 0.15. This guarantee, backed by 20-year performance records, is your assurance of trouble-free turbine operation with Nonpareil.

If you are installing new turbines, let a Standard Oil Lubrication Engineer explain how Nonpareil brings real economy in equipment, plant space, and total investment. Write Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.

STANDARD OIL COMPANY (INDIANA) STA

NONPAREIL
TURBINE OIL

ANA) STANDARD OIL COMPANY (INDIANA) STANDARD

Zero Hardness Oxygen

MEANS
CORROSION-FREE
BOILER PLANT EQUIPMENT

That's where Cochrane Water Conditioning Engineering and Equipment come in . . . to protect from scale and corrosion, the piping, boiler tubes, economizers, etc., of the boiler plants of the world . . . a job they've been doing for 85 years.

COCHRANE

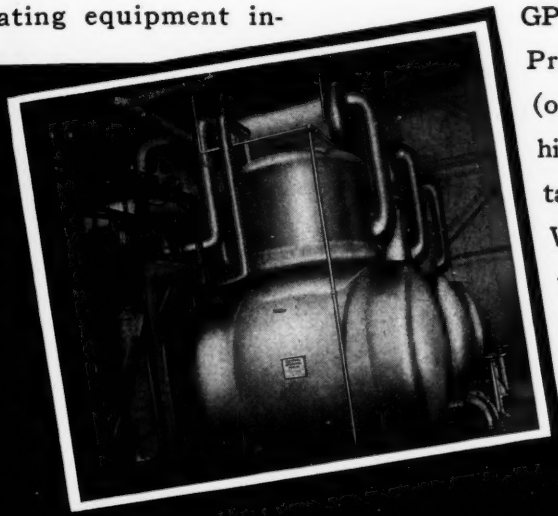
GUARDIAN OF STEAM HORSEPOWER

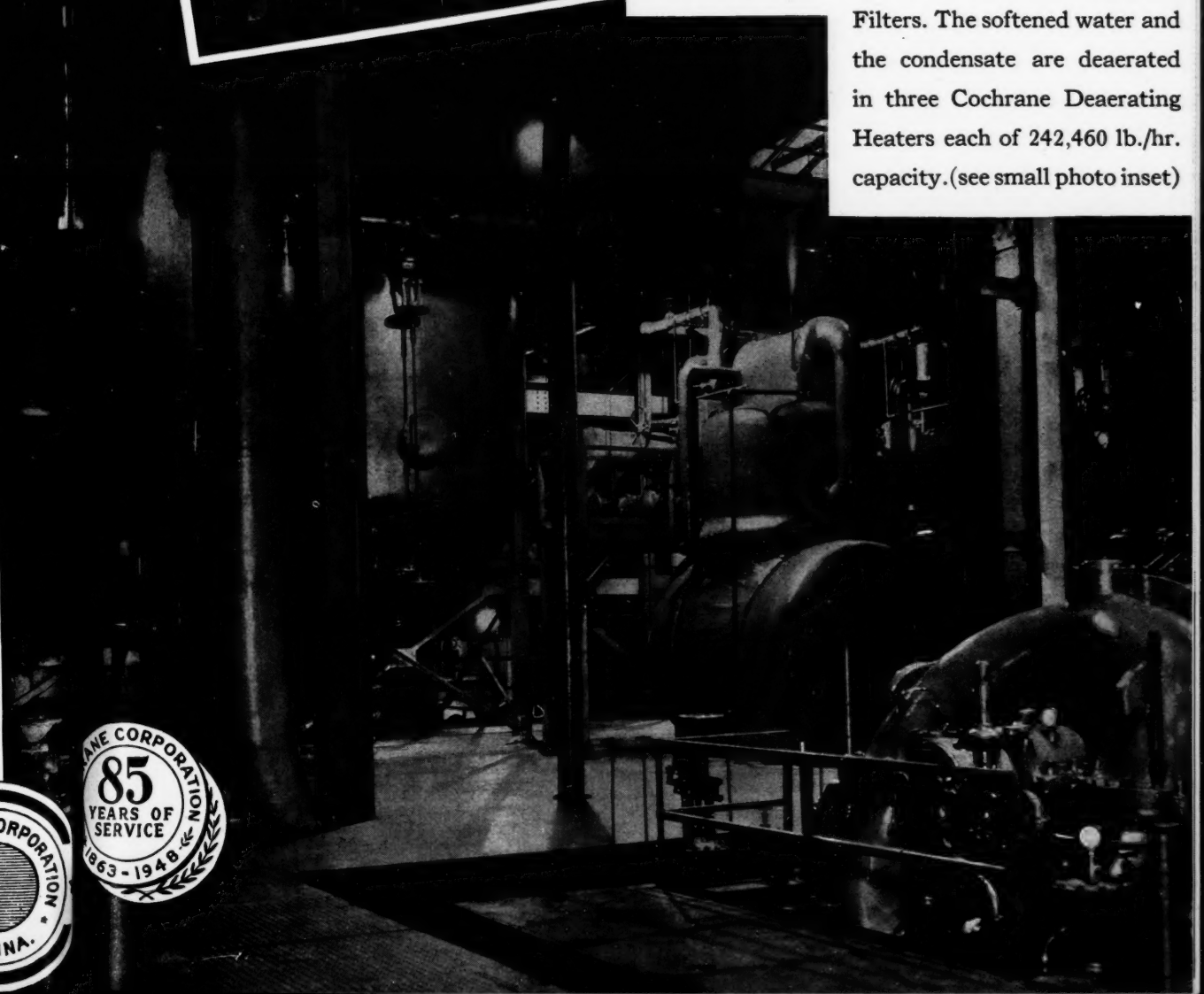
COCHRANE CORPORATION • PENNA.

85 YEARS OF SERVICE 1863 - 194

HOW A GREAT MODERN BOILER PLANT IS PROTECTED AGAINST SCALE AND CORROSION

This installation is interesting in that it shows in practically one view the complete water softening, filtering and deaerating equipment installed to protect the boiler plant of a large steel company located in the Middle West. At the left may be seen two 24,000 GPH Cochrane Hot Process Softeners (one is hidden behind sedimentation tank in foreground). Water supplied to the power plant boilers is drawn from Lake Michigan in a raw state with a hardness of 138 ppm, chiefly bi-carbonates, and with an alkalinity of approximately 106 ppm. The Cochrane unit processes this raw water to zero hardness. The water is first treated with lime and soda ash, after which it passes directly to the second stage in which the effluent from the lime and soda tanks is treated with phosphate chemicals and after settling, the water is filtered through three 8 ft. Cochrane Non-Silite Filters. The softened water and the condensate are deaerated in three Cochrane Deaerating Heaters each of 242,460 lb./hr. capacity. (see small photo inset)





COCHRANE CORPORATION
85
YEARS OF SERVICE
1863 - 1948

"HAS OPERATED 99% OF THE TIME SINCE 1939"

reports the City of St. Mary's, Ohio, of their first 2500 K W Worthington Turbine Generator.

Mr. George Probst
Worthington Pump and Machinery Corporation
Steam Turbine Division
Wellsville, New York

Dear Mr. Probst:

You will be interested, I'm sure, to learn that our new 2500 KW Worthington Turbine Generator has been running continuously since it was put on the line about six months ago.

It's been eight years now since our original 2500 KW Worthington unit was started and it has operated 99% of the time ever since. On a number of occasions, it has carried loads of 3000 to 3500 KW for periods of three to four hours. We run both units a large portion of the time and they parallel very nicely.

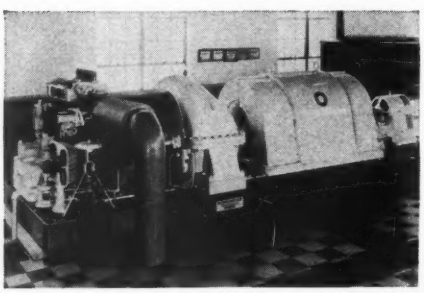
In fact, we do so well with these Worthington units that we would be glad to show them in operation to any of your prospective customers who care to visit our plant.

Very truly yours,
CITY OF ST. MARY'S

F M Hageman

City Engineer and Director
of Service and Safety

New 2500 KW Worthington Turbine Generator recently installed in municipal power plant of the City of St. Mary's, Ohio.



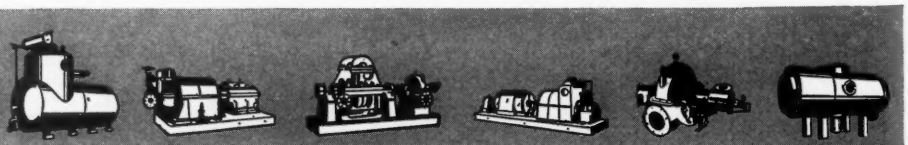
2500 KW Worthington unit installed in 1939. Turbine, straight, condensing type, operates on 400 lbs. steam pressure, 750 degrees total temperature and exhausts into a vacuum of 28"

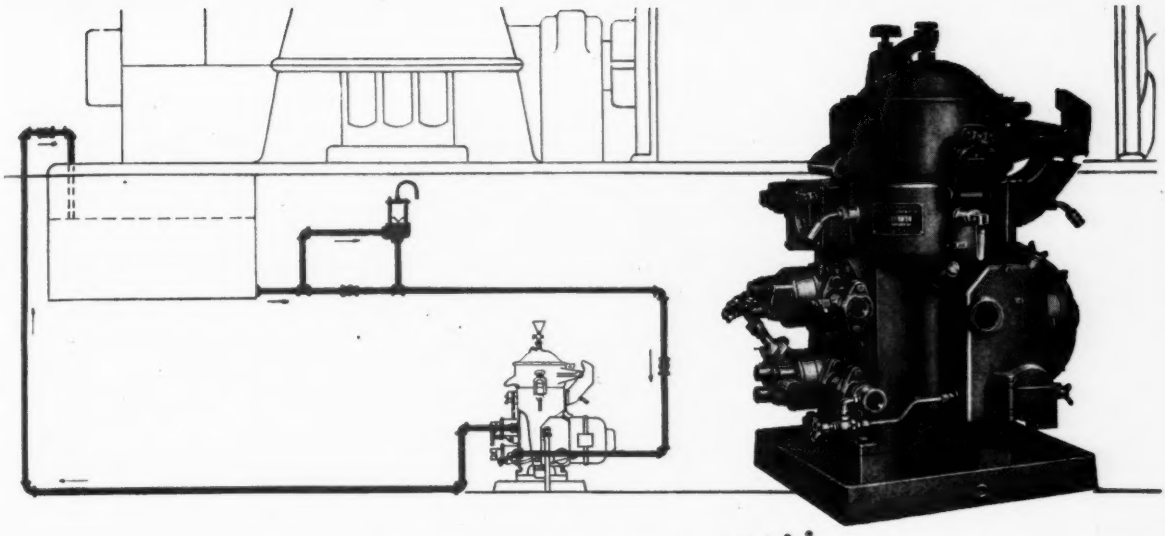
Many similar reports from power users throughout the country testify to the trouble-free, cost-saving performance of Worthington steam turbine equipment. In your own turbine problems, Worthington specialists are always available for expert technical advice. And for further proof that *there's more worth in Worthington*, write for fact-full literature. *Worthington Pump and Machinery Corporation, Steam Turbine Division, Wellsville, N. Y.*

WORTHINGTON

T7-1

A GREAT TEAM IN STEAM





Condensate or dirt—
THIS OIL PURIFIER REMOVES BOTH PROMPTLY

A DE LAVAL Oil Purifier removes water and dirt by means of centrifugal force. Action is entirely mechanical — water is discharged as fast as it is separated from the oil; dirt is stored in the periphery of the bowl, out of the zone of purification.

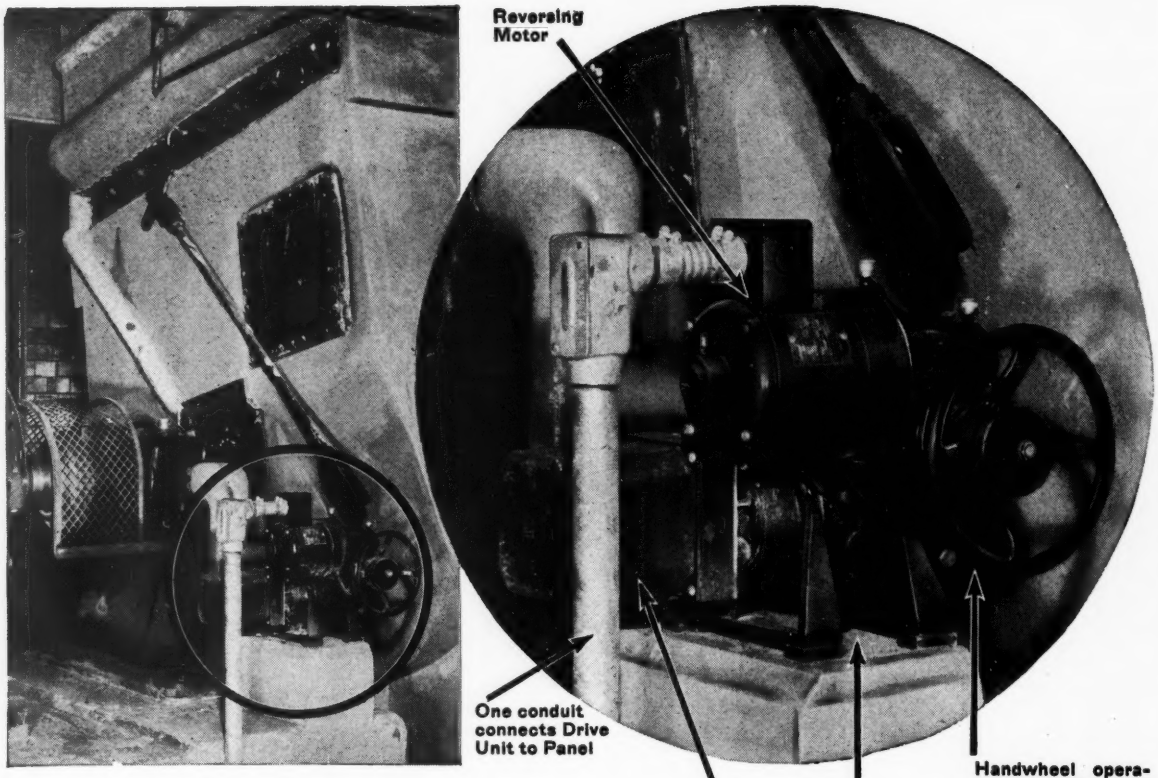
The simplest of all continuous De Laval purification systems is the by-pass system shown above. Such a system utilizes a Purifier for each turbine unit, with a sight overflow glass. As purified oil is pumped back into the oil reservoir, it raises the oil supply level so that the dirtiest oil in the bottom of the reservoir flows through the sight glass to the Oil Purifier. The system may be installed either beneath the turbine (as shown) or on the turbine floor.

A De Laval Oil Purifier of proper size will pass the total quantity of oil in the reservoir through the Purifier three or four times daily, affording full protection to the turbine.

De Laval Oil Purifiers

FOR MORE DEPENDABLE POWER PRODUCTION

THE DE LAVAL SEPARATOR COMPANY
165 Broadway, New York 6 427 Randolph St., Chicago 6
DE LAVAL PACIFIC CO., 61 Beale St., San Francisco 5
THE DE LAVAL COMPANY, Limited, Peterborough, Ont.


Reversing Motor
One conduit connects Drive Unit to Panel
Handwheel operating through gears gives one-man manual control even on heavy dampers or vanes
Reduction train can't be back-driven; locks itself, eliminating lock and release devices
Adjustable Limit Switches stop elements at desired points and/or interlock them with other elements

This **DRIVE UNIT** *Idea*

Solves Many Combustion Control Problems

Many of the advantages which power-plant engineers find in L&N Combustion Controls are due to the Electric Drive Units which move the dampers and other controlled elements.

FUEL ENGINEERS like L&N Electric Drive Units because:

1. They move dampers, etc., smoothly and accurately.

2. Back-driving of units is impossible, no matter how severely the controlled mechanism may become unbalanced.

3. Remote manual control is accomplished by push-button stations at the Panel. Transfer to and from Automatic Control is by a single Selector Switch, for all Units.

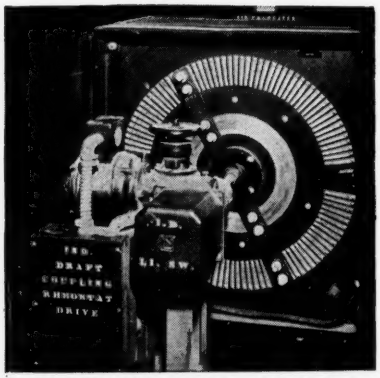
4. Only power needed is the Station's own highly dependable electric supply.

5. Units can always be moved through handwheels. Reduction gears make this easy and also prevent unbalanced elements from snatching the wheel from the operator.

DESIGN AND CONSTRUCTION ENGINEERS like the fact that Drive Units use electric power. No prefabricated stands; only concrete or steel bases.

MAINTENANCE consists mainly of occasional cleaning and oiling.

L&N Combustion Control meets any plant's need, and an engineer will be glad to call on request and describe a suitable system. Address Leeds & Northrup Co., 4973 Stenton Ave., Philadelphia 44, Pa.



On rheostats, drive unit connects to rheostat shaft by flexible coupling—rack and pinion eliminated. Drive units fit any plant layout.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl Ad. NU92(1b)

A GREAT STOKER

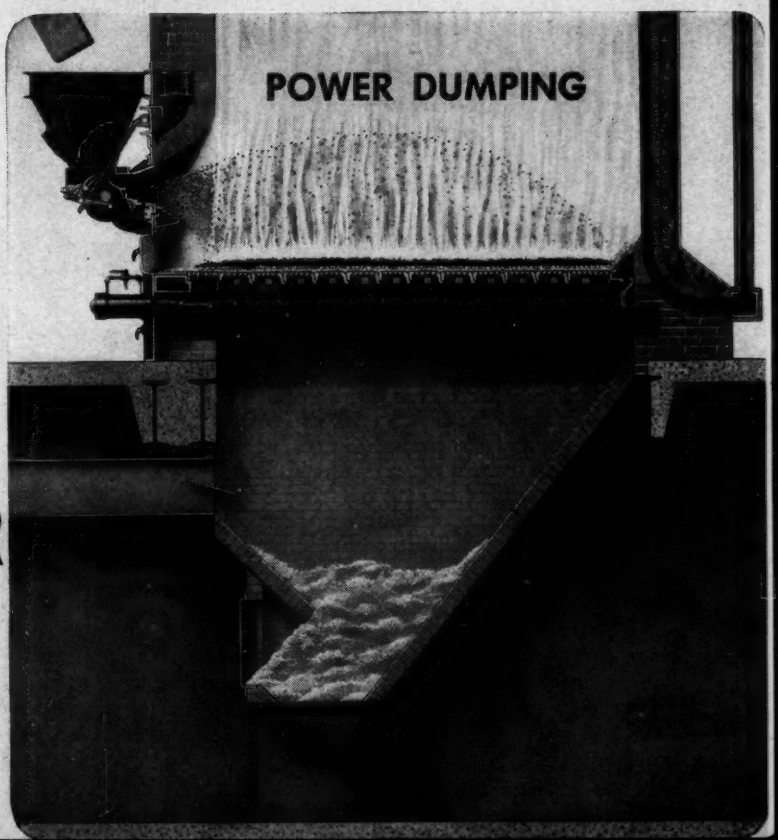
- OVERTHROW ROTORS ASSURE CONTINUOUS AND DEPENDABLE FUEL FEED AND UNIFORM DISTRIBUTION.
- BURNS ALL GRADES OF BITUMINOUS COAL WITHOUT SPECIAL PREPARATION.

DETROIT ROTOSTOKER

For SMALL to MEDIUM Size BOILERS

- STATIONARY
- HAND DUMPING
- POWER DUMPING

GRATES



DETROIT STOKER COMPANY

SALES and ENGINEERING OFFICES
GENERAL MOTORS BUILDING
DETROIT 2, MICHIGAN
WORKS AT MONROE, MICHIGAN

A zillion, trillion miles..at penny-candy cost!

Bells clang, lights flicker, whistles blow as toy trains cover a zillion, trillion miles.

Fun? Just try it yourself!

Cost for this electric power? Casey Jones, Jr. wouldn't miss it from his weekly allowance . . . just a few cents a month!

Electric trains are only one example of the pleasure and everyday convenience Americans enjoy from low-cost electric power. Why? Simple enough! Farsighted investments to gain greater efficiency, plus sound management, have resulted in abundant electric power at a cost we all agree is reasonable.

Improved methods and new equipment are continually studied and applied by power producers to help raise plant efficiency. More people get more power at lower cost.

American Blower is proud to serve the producers of power. Three well-known products—mechanical draft fans, fly ash precipitators and Gyrol Fluid Drives (for draft fans and boiler feed pumps)—help increase power plant output.

If you're planning a new plant or modernization of an old one, you'll want the finest equipment available. Why not send for data on these American Blower products now?

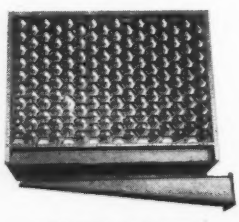
Call the nearest American Blower Branch Office for details—conveniently located in 57 principal cities of the U.S. and Canada.

AMERICAN BLOWER CORPORATION, DETROIT 32, MICH.
In Canada: CANADIAN SIROCCO CO., LTD., WINDSOR, ONT.

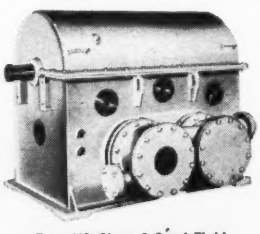
AMERICAN BLOWER

Division of AMERICAN RADIATOR & Standard Sanitary CORPORATION

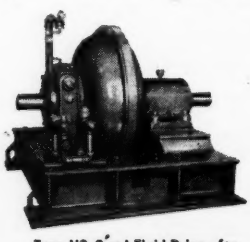
4 American Blower Products to improve overall power plant efficiency



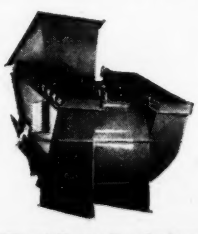
ST Fly Ash Precipitators —especially for power plants burning powdered fuel.



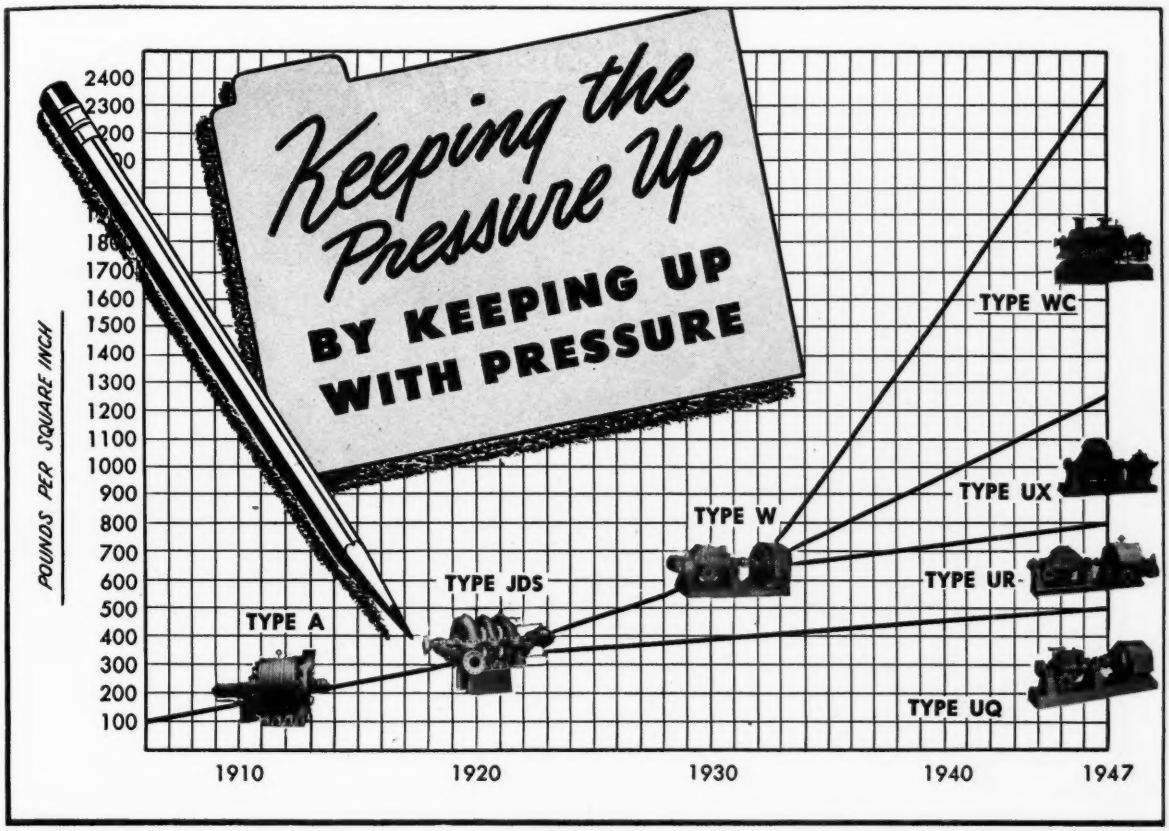
Type VS Class 6 Gyrol Fluid Drive—for adjustable speed control of boiler feed pumps.



Type VS Gyrol Fluid Drive—for adjustable speed control of mechanical draft fans.



HS and Sirocco Fans for forced or induced draft in all types of power plants.



The graph shows you how closely Worthington has kept pace with industry's demands through the years . . . by developing centrifugal pumps to handle steadily mounting boiler feed pressures.

It's a record of steady progress . . . from the old Type A, a great performer at 200 psi . . . to the powerful modern Types WC, UX, UR and UQ, with pressures ranging from 2½ to 12 times the 1910 "ceiling".

THE LONGEST AND BROADEST EXPERIENCE

In addition, out of Worthington's more than 100 years of pioneering in pump design and manufacture have come such notable improvements as the Elastic Seal Ring for tight interstage joints in axially split-case pumps . . . the Metal-to-Metal Ring Type Joint in solid-case barrel pumps.

FOR YOUR OWN BOILER FEED REQUIREMENTS

Worthington has the most complete line of centrifugal pumps — all pressures, all capacities — and engineers trained to fit feed pump to feed cycle for maximum economy and dependability.

For details that prove *there's more worth in Worthington*, contact our nearest District Office. Or write to *Worthington Pump and Machinery Corporation, Centrifugal Pump Division, Harrison, N. J.*

MEMBER

WORTHINGTON

C7-9

THE WORLD'S LARGEST MANUFACTURER OF PUMPS

For Boiler Feed Service
Capacities to 1500 GPM
Heads to 1000 Ft.

For Hotwell, Condensate, Chilled Water Service
Capacities to 1400 GPM
Heads to 650 Feet

For Boiler Feed Service
Capacities to 1500 GPM
Heads to 1600 Feet

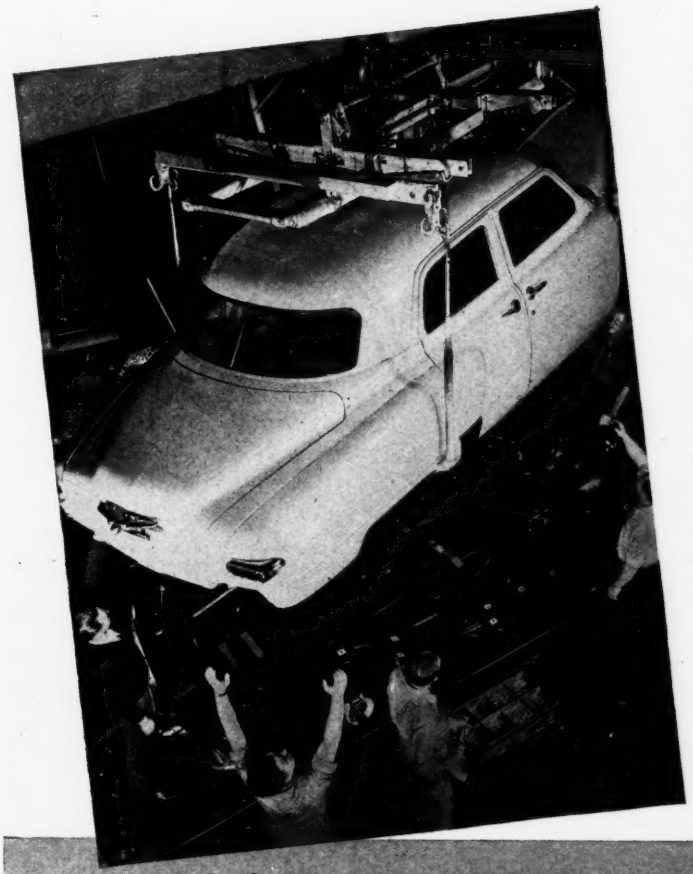
For Water Works, Circulation, Drainage, General Service
Capacities to 135,000 GPM
Heads to 400 Feet

For Boiler Feed Service
Capacities to 1600 GPM
Heads to 3500 Feet

For Boiler Feed Service
Capacities to 3000 GPM
Heads to 7000 Feet

1st
2nd
3rd

FW UNIT FOR STUDEBAKER



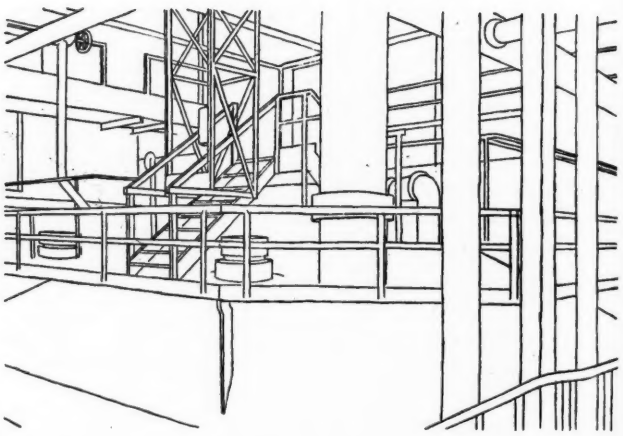
To meet the unprecedented demand for post-war automobiles, reliable and efficient steam generation is a "must" at The Studebaker Corporation's South Bend, Indiana plant. When plant expansion necessitated additional steam capacity, a third steam generating unit, a duplicate of the first two, was ordered from Foster Wheeler.

Regardless of finished product, whether automobiles, typewriters or electric power, a reliable and efficient source of steam is assured by Foster Wheeler steam generators. They are backed by years of experience in producing successful designs over the complete range of sizes.

FOSTER WHEELER CORPORATION
165 BROADWAY • NEW YORK 6, N. Y.

FOSTER WHEELER CORPORATION

What determines



ONE of the more simple problems in boiler water pre-treatment is that presented by well water which contains large amounts of dissolved carbon dioxide, temporary hardness and silica, plus the other constituents normally present in well water.

Even this apparently simple problem may, however, be complicated by many factors. Softening is obviously required, but should it be by hot process, base exchange, cold sludge contact, or some combination of these methods? In part the answer will depend on the pressure of the boilers, the ratings at which they are to be operated, and the ways in which the steam is to be used. In part it may depend on other factors, some of which may be common to many plants, while others may be conditions peculiar to a single plant.

In one plant, for example, most factors pointed toward the use of a hot process softener—but the treating plant had to be located some distance from the boiler room. This fact in itself was enough to tip the scales in favor of a cold process. Since the requirements of the plant called for very thorough removal of silica, the final recommendation was to use sludge contact equipment to reduce silica content, then to finish up with base exchange softening.

Sometimes, however, removal of silica may be exactly the wrong thing to do. Hall records show many such instances. One typical case is that of a large plant in the Pittsburgh area, using treated river water. This plant had no difficulty in keeping boiler tubes clean during the winter, but found them dirty at the time of summer inspections.

Adding silica cleared up the trouble. Hall Laboratories prescribed this procedure because they knew that the higher acidity of the river water during the summer months made it

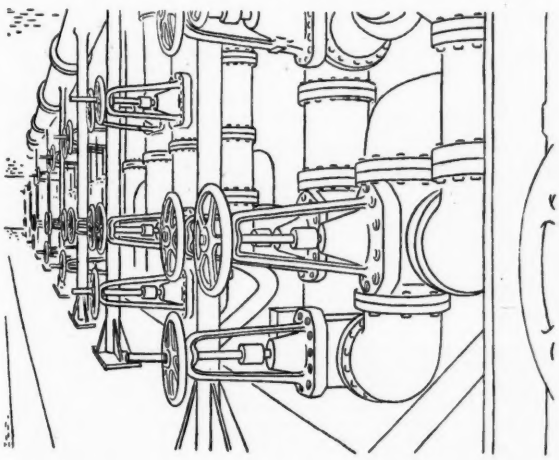
HAGAN
HALL
BUROMIN
CALGON

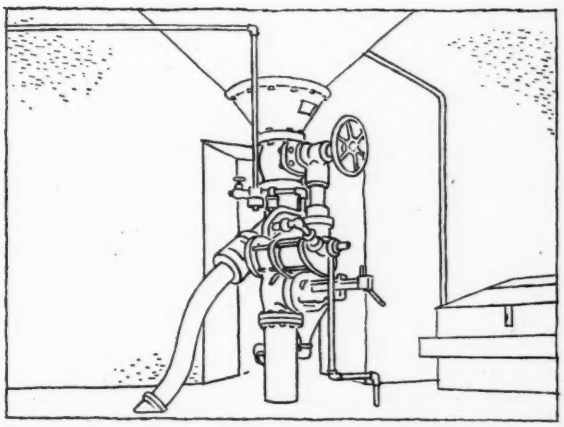
pre-treatment procedures?

deficient in silica, and that silica-deficient water produces a sticky, adherent sludge.

When water is deficient in silica, the accumulations on softener filter beds may seriously impair the efficiency of the filter. In many cases addition of the right amount of silica to the water produces a sludge which can be easily and fully removed by ordinary backwashing. In some cases, this treatment has increased filter efficiency to such an extent that investment in additional filter capacity was avoided.

These incidents illustrate a few of the factors that must be considered in prescribing pre-treatment procedures—and pre-treatment is only one of the many problems in the industrial use of water.





Hall Laboratories offers a complete service, covering not only boiler water conditioning but also the treatment of service and process waters, re-use or disposal of waste waters—and every other industrial water problem. They are prepared to recommend procedures which, taking all factors into account, represent the most efficient and economic course *in your specific situation.*

Correspondence on any industrial water problem is invited. Hall Laboratories, Inc., Hagan Building, Pittsburgh 30, Pa.

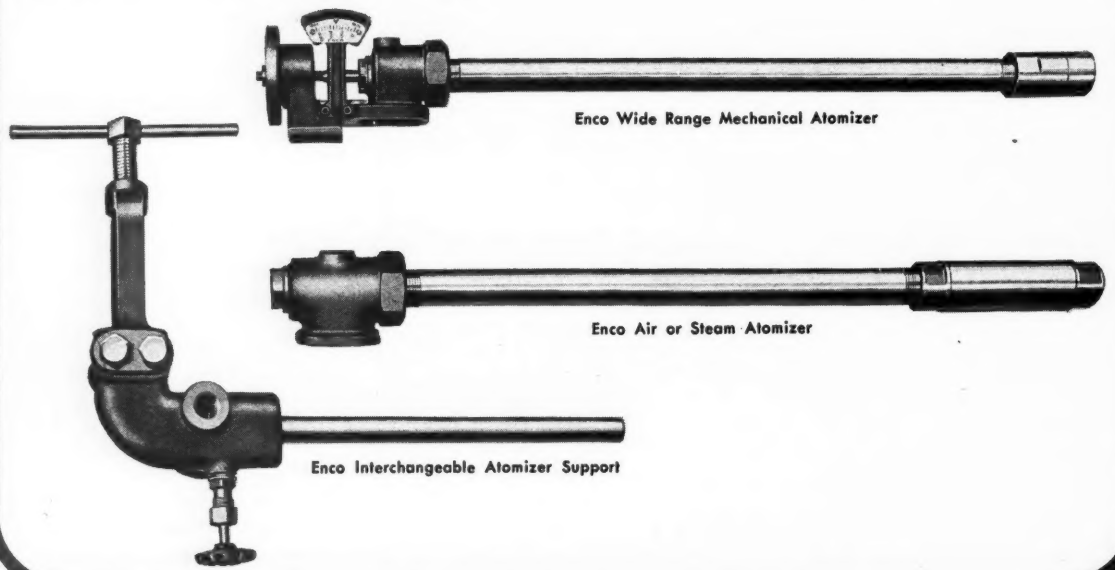
HALL LABORATORIES, INC.

(A Subsidiary of Hagan Corporation)

CONSULTANTS ON
INDUSTRIAL WATER TREATMENT
HALL SYSTEM OF BOILER WATER CONDITIONING
INDUSTRIAL WASTE RECOVERY AND DISPOSAL

For Better Combustion Practice Use

ENCO INTERCHANGEABLE ATOMIZERS



Enco Wide Range Mechanical Atomizer

Enco Air or Steam Atomizer

Enco Interchangeable Atomizer Support

Interchangeable Enco Fuel Oil Atomizers are improving combustion practice in more and more progressive boiler rooms. Designed for exceptionally wide capacity ranges with all grades of liquid fuels, they eliminate burner tip changes, through the entire load range.

1. *Wide Range Mechanical Atomizers*—With a capacity range of 10 to 1—controlled manually at atomizer or automatically from remote station—*constant high oil pressure at atomizer insures efficient atomization over entire load range without recirculating or returning oil.*
2. *Steam or Air Atomizers*—Capacity range of 10 to 1—controlled by manual or automatic pressure regulation.

Both atomizers are designed to fit the Enco Interchangeable Atomizer Support. Enco Straight Mechanical Atomizers are also available.

Enco Fuel Oil Atomizers are built to give most economical, efficient service for any type pulverized coal, gas or oil-burning air register as well as for stoker-fired and industrial type furnaces. They can also be used independently for special applications.

The Engineer Company maintains a research and planning staff to help you improve your combustion practice. Literature completely describing any Enco product will be sent on request.

EC-473

THE ENGINEER COMPANY
ALSO PRODUCES:

Enco Air Registers
Enco Fuel Oil Pumping and Heating Units
Enco Automatic Oil-Electric Ignition Systems
Enco Automatic Combustion Controls
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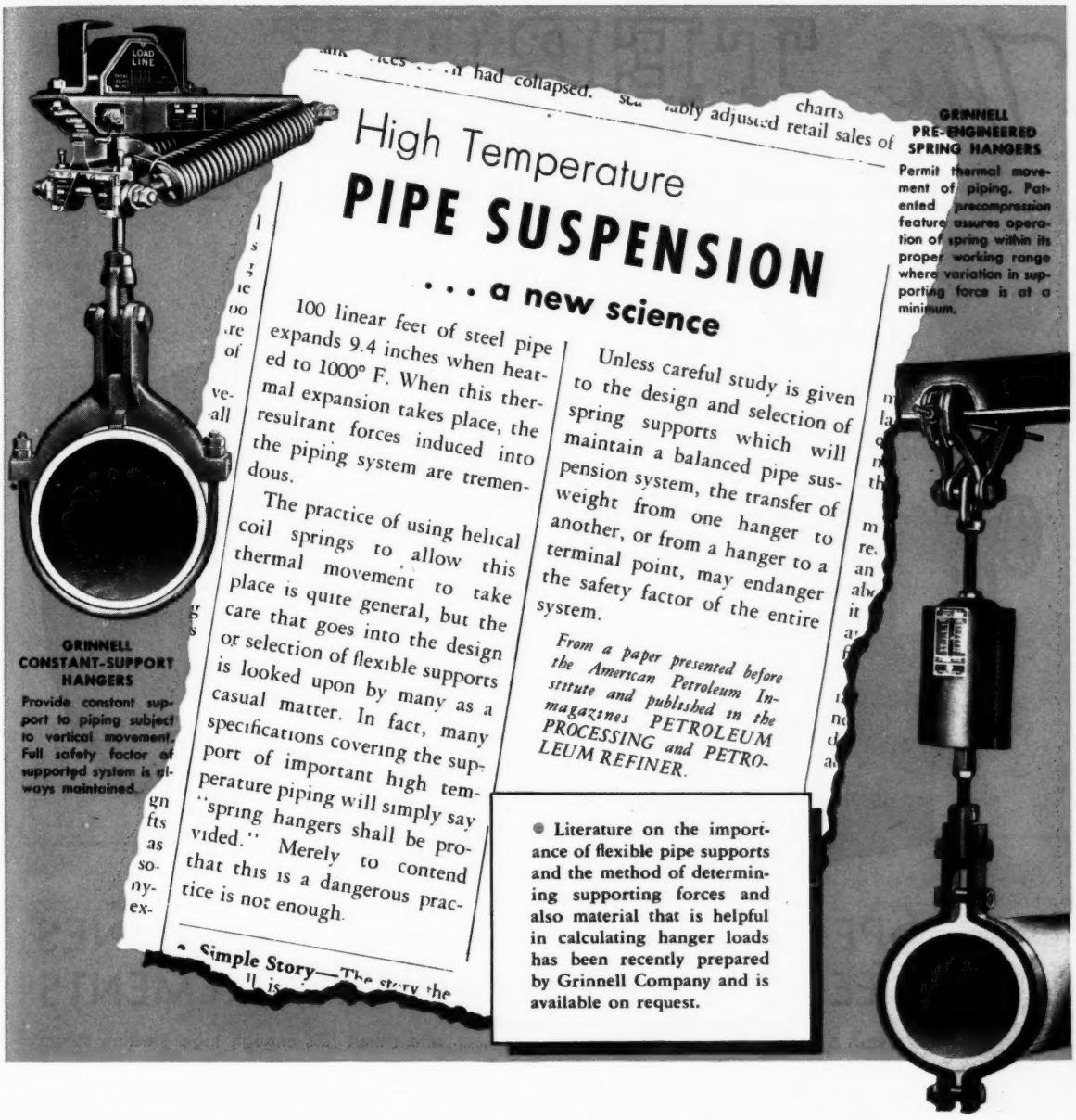
had collapsed.
charts
adjusted retail sales of
High Temperature
PIPE SUSPENSION
. . . a new science
100 linear feet of steel pipe expands 9.4 inches when heated to 1000° F. When this thermal expansion takes place, the resultant forces induced into the piping system are tremendous.
The practice of using helical coil springs to allow this thermal movement to take place is quite general, but the care that goes into the design or selection of flexible supports is looked upon by many as a casual matter. In fact, many specifications covering the support of important high temperature piping will simply say "spring hangers shall be provided." Merely to contend that this is a dangerous practice is not enough.
Unless careful study is given to the design and selection of spring supports which will maintain a balanced pipe suspension system, the transfer of weight from one hanger to another, or from a hanger to a terminal point, may endanger the safety factor of the entire system.
From a paper presented before the American Petroleum Institute and published in the magazines PETROLEUM PROCESSING and PETROLEUM REFINER.
Literature on the importance of flexible pipe supports and the method of determining supporting forces and also material that is helpful in calculating hanger loads has been recently prepared by Grinnell Company and is available on request.
GRINNELL CONSTANT-SUPPORT HANGERS
Provide constant support to piping subject to vertical movement. Full safety factor of supported system is always maintained.
GRINNELL PRE-ENGINEERED SPRING HANGERS
Permit thermal movement of piping. Patented precompression feature assures operation of spring within its proper working range where variation in supporting force is at a minimum.

GRINNELL OFFERS A COMPLETE PIPING SERVICE

PIPING SUPPLIES

- Pipe, Valves and Fittings
- Engineered Pipe Hangers
- Grinnell-Saunders Diaphragm Valves
- Thermolier Unit Heaters
- Prefabricated Piping
- Plumbing and Heating Specialties
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OTHER GRINNELL PRODUCTS

Automatic Sprinklers and Special Hazard Fire Protection Systems

AMCO Humidification and Cooling Systems

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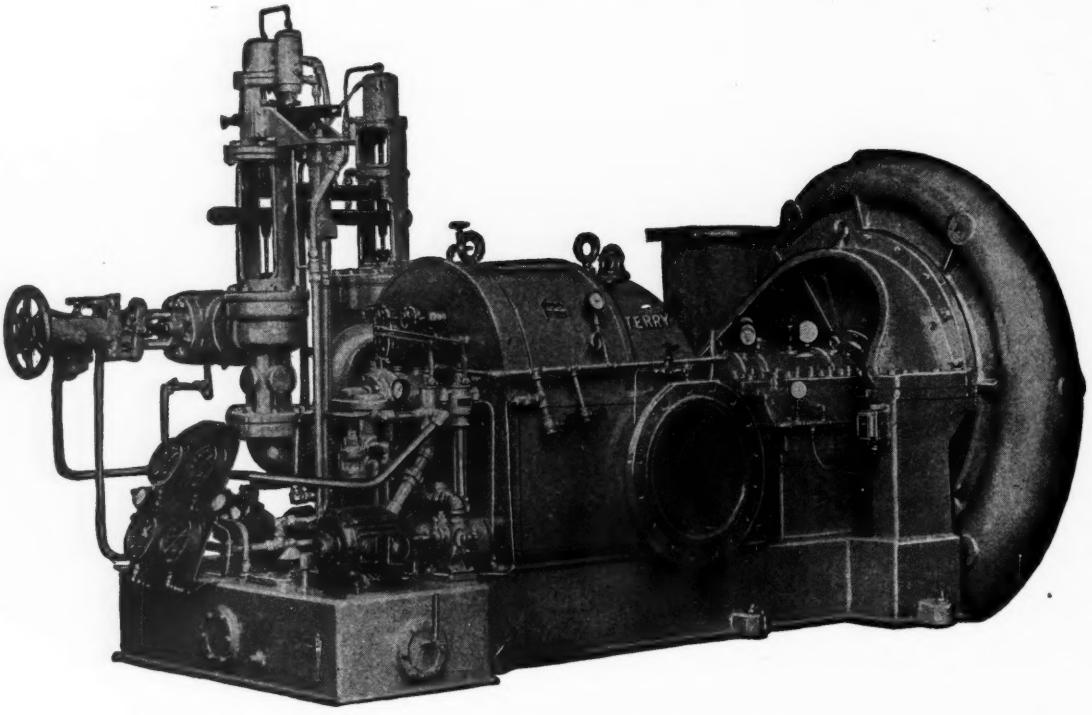
GRINNELL

WHENEVER **PIPING** IS INVOLVED

The TERRY TURBINE



SPECIAL MULTI-STAGED TURBINES ENGINEERED TO FIT YOUR REQUIREMENTS

Pictured above is a typical special purpose Terry Turbine. This unit is rated 332 H.P. and can be operated under any of the following conditions:

(1) As a straight high pressure condensing turbine.

(2) As a straight low pressure condensing turbine, thereby converting any excess low pressure steam into power.

(3) As a mixed pressure turbine. It will then absorb all the low pressure steam available and admit just enough high pressure steam to carry the load.

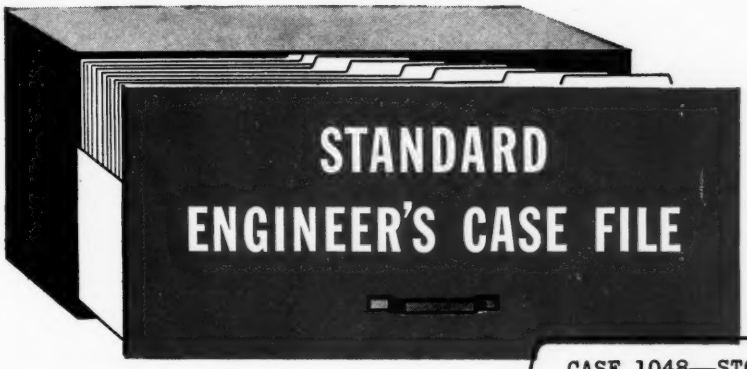
(4) As a condensing bleeder turbine. It will supply clean low pressure steam for heating or process work.

(5) Under all conditions the speed can be varied from 2800 R.P.M. to 4750 R.P.M.

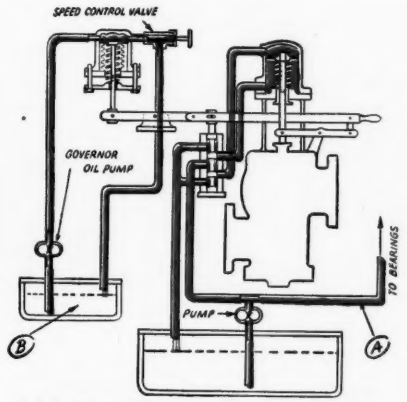
If you have an application for a special purpose multi-staged turbine, Terry will be pleased to discuss the details and make recommendations. Terry Turbines are built in all sizes up to 2000 H.P.

T 1161

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.



CASE 1048—STOPPING RUSTING, LACQUERING, SLUDGING IN STEAM TURBINES.



VARIABLE-SPEED OIL-RELAY GOVERNOR

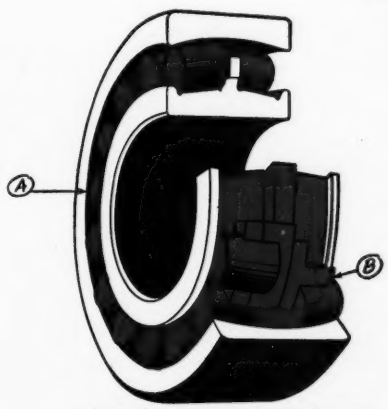
Charges of inhibited Calol OC Turbine oil in various size turbines gave service many times longer than normally obtained with straight-mineral oils. Use in large and small units ... ring-oilers, circulating oil lubricating systems and oil-actuated governor relay systems. Comes in five grades: 5, 9, 11, 15, 19.

A. Contains highly effective corrosion inhibitor and has excellent metal-wetting ability. Keeps moisture in oil systems from contacting metal.

B. Oxidation inhibitor resists deterioration of oil and sludge formation caused by heat, moisture, air, dirt ... prevents plugging of oil lines.

Calol OC Turbine Oil in regular service showed no increase in acidity after several years ... turbine parts remained in same condition as when installed ... water and solid contaminants separated readily from oil in centrifuging or filtering systems.

CASE 1050--PROVIDING FLUID LUBRICATION IN ANTI-FRICTION BEARINGS WITHOUT LEAKAGE.



HEAVY-DUTY ROLLER BEARING

Heavy-duty industrial roller bearings started easier and ran freer when lubricated with Calol Grease BRB-340. Specially-made for all anti-friction bearings. Apply with grease gun or by packing.

Has unusual ability - softens around roller and balls in bearings to oil-like viscosity but remains firm on outer parts. Resets quickly so oil swept aside by moving bearing parts keeps firm outer seal of grease intact.

A. Soft consistency around moving parts of bearings lowers starting torque and reduces internal friction.

B. Firm grease forms seal that helps prevent leakage.

High resistance to deterioration under high speed conditions and extreme temperatures provides exceptional lubrication over extended periods of operation.

For additional information and the name of your nearest Distributor, write

STANDARD OIL COMPANY OF CALIFORNIA
225 Bush Street, San Francisco 20, California

The California Oil Company
30 Rockefeller Plaza, New York 20, N. Y.
The California Company
17th and Stout Streets, Denver 1, Colo.
Standard Oil Company of Texas
El Paso, Texas

RPM CALOL

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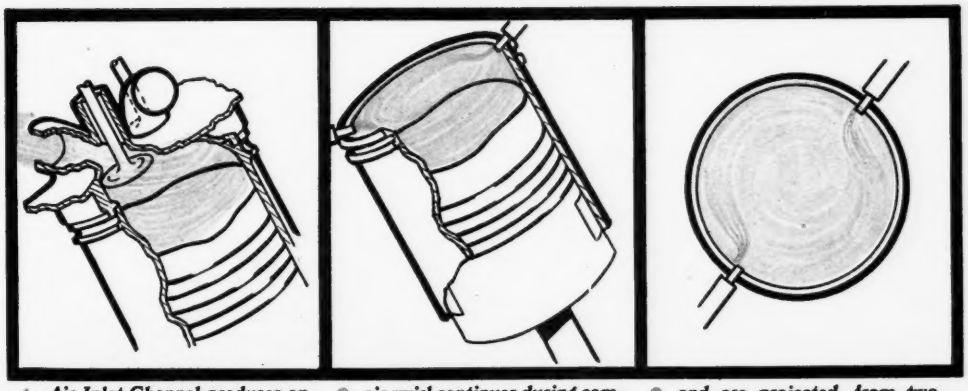
TUBE CLEANERS

In all our 38 years of specialization in the manufacture and sale of tube cleaners, none can even remotely approach the power, efficiency, and cleaning speed of the new ROTOJET. Send for new bulletin showing the complete range of sizes for operation with water, air, and steam.

ELLIOTT COMPANY—ROTO DIVISION
147 SUSSEX AVENUE NEWARK 1, N. J.

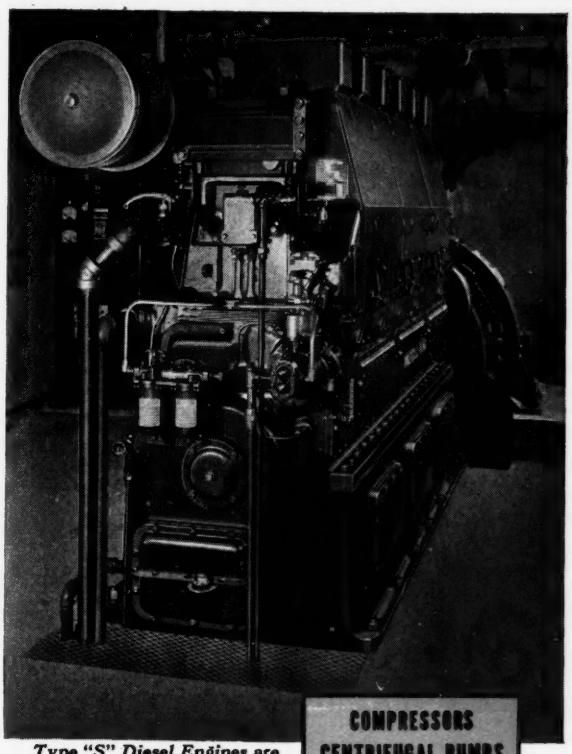
THERE'S A *Compound Cyclone* IN THE CYLINDER EVERY TIME THIS DIESEL FIRES



1 *Air Inlet Channel produces an air swirl during intake. This...*

2 *air swirl continues during compression. Fuel sprays are also whirling...*

3 *and are projected, from two points, across the path of the air swirl. Extreme dispersion or atomization results.*



Type "S" Diesel Engines are 4-cycle units built in 3, 4, 5, 6, 7 and 8-cylinder sizes for 225 to 600 hp. All sizes operate at 720 rpm.

Here's the reason for complete combustion in the type "S" Engine

One of the factors most necessary for complete combustion in Diesel Engines is the turbulance and dispersion which brings fuel particles into intimate contact with combustion air. Good turbulance and dispersion can be achieved only by a planned and violent motion of air and fuel. The diagrams above show how Ingersoll-Rand engineers arranged for a *whirling spray of fuel* to be injected, at two points, across the path of a *swirling charge of combustion air.*

Rotational Turbulance... Compound Cyclone... call it what you will... it makes for good economy. This unique combustion principle is the result of twenty-six year's of experience in Diesel building. This feature, together with a scientific cooling system, and full force-feed lubrication, make the Type "S" Diesel one of the outstanding engines in its power range.

We would like to give you more details, and will be glad to send you a copy of a booklet which tells the full story. Ask for Bulletin 10,310.

COMPRESSORS
CENTRIFUGAL PUMPS
OIL & GAS ENGINES
TURBO BLOWERS
CONDENSERS
AIR TOOLS
ROCK DRILLS

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y. 7-760

THE C-E PACKAGE Gives Top Performance at Minimum Cost

Here's why . . .

The C-E Package Boiler was *designed* [illegible] *service* – industrial loads, particularly in plants having small operating and maintenance forces. Consequently, every element is combined in *balanced relationship* to produce definitely planned operating advantages – efficiency over a wide range of output, ability to take rapid load swings, the production of steam of satisfactory quality at all ratings, together with simplicity of operation and minimum maintenance.

No assembled compromise could insure such results. Required is the complete coordination of all components – *balanced design* – by a single manufacturer who controls every element of design and construction. C-E does this, and with *one* contract, *one* guarantee and *one* responsibility, provides the top performance you have a right to expect from years of leadership in steam generating equipment.

Moreover, you gain the benefit in the purchase price of the savings made possible by standardized design. And in efficiency, simplicity of operation and low maintenance, you have added savings that lower costs substantially.

It is not surprising that plants in widely different industries have selected the boiler of balanced design for top performance at minimum cost.

If you are in need of new steam generating equipment it will pay you to investigate the advantages of the C-E Package Boiler. B-157

Fully descriptive catalog on request.

Partial list of industries that have selected the C-E Package Boiler during the past year:

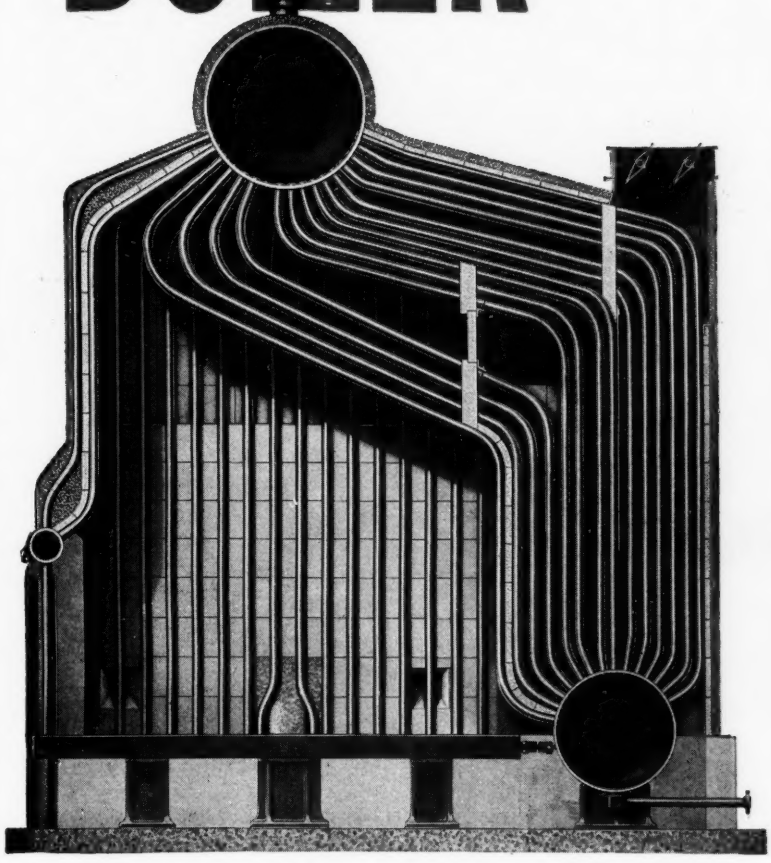
Bakery	Leather	Paper
Chemical	Linoleum	Railroads
Dairy	Machinery	Rubber
Glass	Metals	Textile
Hospital	Packing	Tobacco
Hosiery	Paints	Utility

COMBUSTION ENGINEERING

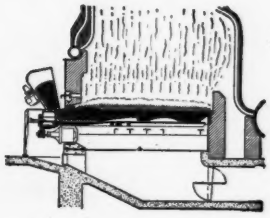
C-E PRODUCTS INCLUDE ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; ALSO MANY TYPES OF PRESSURE VESSELS

200

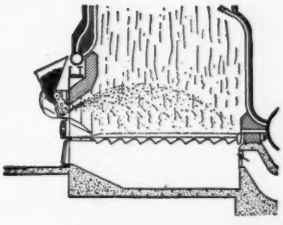
BOILER



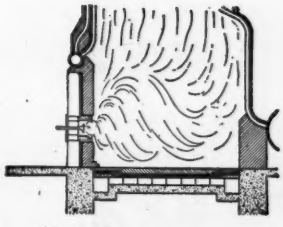
Furnished in capacities of
15,000 to 50,000
lb of steam per hr
the Package Boiler is designed for four methods of firing — spreader stoker, single-retort underfeed stoker, oil or gas burners. Any of these methods may be substituted for any other should a change in the fuel market occur.



Type E Underfeed Stoker



Spreader Stoker



Oil or Gas Burner

MAINTENANCE ADVANTAGES

1. Any tube in the furnace or boiler convection bank can be removed and replaced without disturbing any other tube.

2. Amply sized tubes reduce tendency for solids to deposit and are easier to clean. All tubes can be de-scaled from top drum.

3. Integral soot blowers enable the operator to keep tube surfaces clean.

4. Front and side walls of the furnace are fully water-cooled, virtually eliminating refractory maintenance.

ENGINEERING

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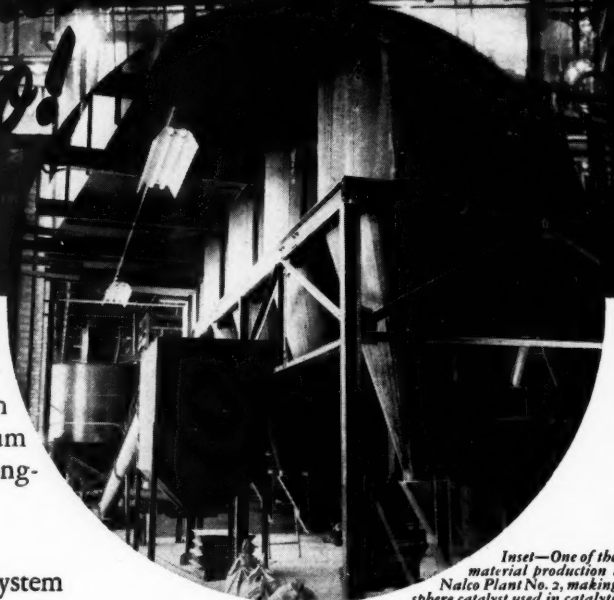
in the PETROLEUM INDUSTRY

permanent water treatment results are obtained by the



Inset—One of the special material production lines at Nalco Plant No. 2, making microsphere catalyst used in catalytic petroleum cracking processes.

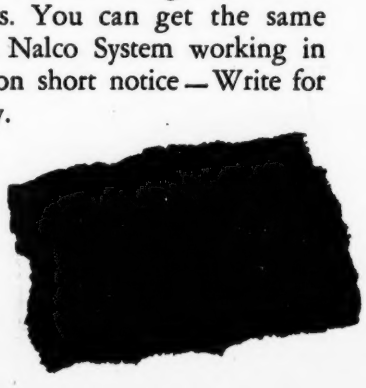
For a quick estimate of water treatment results the Nalco System is getting throughout the Petroleum Industry, check this record of long-term usage . . .

51% of all Nalco System refineries have been using Nalco for more than *5 years!*

44% of the above refineries have been sure of Nalco water treatment results for *over 10 years!*

42% of refineries in the over-10-years group have enjoyed Nalco Service *over 15 years!*

Here is positive evidence that the progressive Nalco System produces **permanently successful water treatment results . . .** in large and small installations. You can get the same trouble-free Nalco System working in your plant on short notice—Write for details today.



NATIONAL ALUMINATE CORPORATION

6224 W. 66th Place, Chicago 38, Illinois

Canadian inquires should be addressed to Aluminate Chemicals, Ltd.
555 Eastern Avenue, Toronto 8, Ontario

—the Scientific System of Water Treatment for All Industry

HELPFUL BULLETINS

Answers to many operating and maintenance problems will be found in these new bulletins and catalogs. List paragraph numbers of those you want on coupon below, detach and mail

BOILERS

1 **Boilers**—A line of boilers is described in this well designed 24-page bulletin. The various sections of the boilers are photographed separately for better observance of their features. Included are two pages of drawings of boilers for all firing methods. It is shown how the boilers efficiently burn gas or oil. Also included is a clearance and dimension sketch, a table of dimensions and a listing of specifications for the boilers. Photographed are typical installations. Erie City Iron Works.

INSTRUMENTS, CONTROLS

2 **Chlorine and pH Control**—In addition to descriptions of the various comparators for pH, chlorine and phosphate control for water analysis, this 96-page book contains simple and technical discussions of the meaning of pH control, the applications of pH, chlorine and phosphate control to many different industries and precautions which must be observed in making determinations. Control of boiler water treatment is discussed, including pH, phosphate and nitrate, and equipment is recommended for this purpose. W. A. Taylor & Co.

3 **Boiler Water Level Control**—Bulletin No. 473, 8 pages, contains information on boiler water level control in the municipal power plant of the city of Monroe, Louisiana. Contained are typical installation photographs. Presented is signicant data on high-pressure extension and a full-page cross-sectional boiler diagram. The method of installation of a Copes flowmatic regulator is diagrammed. A steam-flow chart and a water-level chart complete the booklet. Northern Equipment Co.

4 **Instrument Catalog** — This excellent 48-page instruments catalog No. 110 contains a complete line of industrial thermometers and other instruments. Each instrument is illustrated and well described together with dimensional tables. Bulletin contains such items as dimension drawing of industrial type mercury thermometers, case and drilling dimension drawings for round form recorders, rectangular form recorders and dial thermometers, a Moeller chart showing uniform scale graduations, a fahrenheit chart and centigrade, and reverse reading and reaumur charts. Moeller Instrument Co.

5 **Extensometers** — Bulletin 263, 12 pages, describes, illustrates and gives specifications of a line of extensometers and accessories. Enlarged photographs indicate more important parts, and show how extensometers are operated. Included is a complete list of testing equipment made by the manufacturer. Baldwin Locomotive Works.

6 **Regulators**—A complete line of type AFR feeder voltage regulators is described in this 24-page bulletin. The construction of the units is shown and described, accompanied by a diagram of the unit assembly, and a photograph of the balanced spring principle. Included are line diagrams of the regulator control circuit and the theory of operation. The automatic control feature is amply explained. Many graphs are shown. Two pages of standard ratings complete this well designed bulletin. Allis-Chalmers Mfg. Co.

7 **Water Columns and Gages** — Contained in Bulletin WG-1811, is engineering data on this line of water columns and gages. Drawings and text describe the construction details of columns, try-cocks, and gages. The flat glass inserts for water level gages are described and illustrated as are the column and gage arrangements for pressures above 400 lb. The dimensions and prices are contained in a two-page spread. A spare or repair parts list is included and diagrammed. Typical installations are photographed. Yarnall-Waring Co.

8 **Flow Indicators**—For use in water treatment, sewage purification and industrial waste treatment. Applications, principles, operation, and specifications are described in this Bulletin No. 1070-A. Infilco, Inc.

9 **Indicating Recorders and Controllers** —For instrument men in scientific laboratories and industrial plants, this catalog ND 44(2), 16 pages, will serve as a handy guide to all the company's round-chart "Micromax" instruments. Included are complete specifications in tabular form for automatic indicating recorders, and indicating and recording controllers. Suggested chart numbers are listed for the more commonly used ranges, together with other accessories and supplies. Included are drawings and photographs to illustrate the text. Leeds & Northrup Co.

10 **Flow Rate Control**—Folder 113 is a 4-page bulletin on a line of controls with strainer attachment for flow rate control of water, oil, gas and air. The female iron pipe, the flared copper tube and the solder connection controls are shown. The advantages of using the controls are stated. Bulletin closes with four diagrams showing how to clean strainer. Hays Mfg. Co.

11 **Steam and Liquid Control**—Featured in this 4-page Catalog 48MC is engineering data on lines of precision pressure regulators, temperature regulators, combination pressure and temperature regulators, self-cleaning strainers and steam traps. It includes dimensions, application, capacity and engineering tables and specifications. Drawings show cut-away views of various models. Other diagrams show typical installation arrangements. O. C. Keckley Co.

12 **Low-Resistance Test Set**—A way to test bond and other resistances as low as 0.000002 ohms against a predetermined standard is described in Bulletin LRT-1. Various sets with photographs, and a full scale range in ohms of each type, with price, are shown. Drawings of test set accessories conclude the bulletin. A test set data sheet for use by the reader is included. Shallcross Mfg. Co.

TREATMENT

13 **Handbook of Water Conditioning**—A 60-page reference Bulletin No. G-1 which has been brought up-to-date to include the most recent developments in the design of water treatment and liquid conditioning equipment. Included in the material are tables listing the various kinds of gaseous and solid impurities, showing the effects, limits of tolerance for various purposes, methods of removal and residual amount of each impurity after treatment. A comparison chart shows the chemical results produced by various water treatment methods. More than three dozen diagrams illustrate the principles of construction and operation of the various processes and equipment for softening, clarification and demineralizing of water and other liquids. Liquid Conditioning Corp.

14 **Boiler Water Treatment**—A system of complete boiler water treatment is described in this 8-page bulletin. It is shown in a series of 6 photographs how an investigation is made at the boiler plant to gather the necessary data and to determine the conditioning required, and how the technical department studies water analysis and plant data. A discussion follows on "how complete boiler water treatment functions." Bulletin concludes with a diagram of a boiler which provides a proving ground for the research department of the company. E. F. Drew & Co., Inc.

15 **Fuel Oil Treatment** — Presented in this 4-page bulletin is engineering data on a fuel oil treatment for the prevention and correction of unsatisfactory conditions in the storing, pumping, heating and burning of industrial fuel oil. Shown are two large drawings which help explain when the "Ameroid" fuel oil treatment is used. Also discussed is the problem of sludge and a simple experiment shows how the treatment helps eliminate this nuisance. The application of the treatment is thoroughly explained. E. F. Drew & Co., Inc.

PUMPS

16 **Centrifugal Pumps**—Four and six stage volute centrifugal pumps are described in this 6-page Bulletin 241. Complete engineering data contains cross-sectional drawings of the pumps, metal specifications table, and line drawings with accompanying dimensional table. Typical installations are shown. Warren Steam Pump Co., Inc.

17 **Pump Catalogs**—Contained in this folder are a number of excellent catalogs describing a line of rotary piston positive displacement pumps having the exclusive tri-rotor principle. The various catalogs include information on the 200A, 90C, 100C, 80B, 40A and 20D series pumps and also truck pumps. The first booklet shows typical installations using the pumps along with a data sheet for ordering proper pump. Other booklets contain installation drawings, operating charts, uses and applications, detailed descriptions, capacities and photographs of the various pumps. The last booklet of 16 pages includes complete engineering data for pump installations. First discussed is general information on pump installations; then shown are suction line, discharge lines and hp calculations; following are numerous diagrams of pumps; 14 tables include all necessary engineering data; closes with 3 pages of materials recommended for pumping various liquids. The Yale & Towne Mfg. Co.

18 **Sewage Pumps**—A line of centrifugal sewage pumps with single blade impeller is described in this 4-page Bulletin No. 237. A general description of the pumps is followed by an explanation of the specifications for horizontal and vertical single blade impeller. A view shows the rotating element. Two drawings illus-

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trate typical non-clogging sewage pump installations. American Well Works.

19 **Centrifugal Pumps** — Contained in this 4-page Bulletin No. 251 is valuable engineering data on a line of centrifugal pumps. The design features are explained and illustrated by a cut-away drawing. Included is a full page single suction pump capacity rating table, and specification drawings accompanied by a dimension table. A compilation of suggested specifications concludes the bulletin. American Well Works.

MAINTENANCE

20 **Resurfacer** — A heavy-duty material for repairs and overlays to concrete and wooden floors. This folder lists the characteristics of the material, and describes and illustrates several applications in solving floor problems for various industries. Stonhard Co.

21 **Varnishes and Coatings**—A new bulletin of 10 pages on Insl-x insulating varnishes and coatings is being distributed. The detailed physical and chemical properties with instructions for application are included for: E series for electrical coil, bus bars, flexible wire and small tools; U series for phenolic, ceramic and metal surfaces and sealing; M series for moisture and mildew proofing; and the hot melt series of moisture resistant dielectric sealants. The Insl-X Co., Inc.

VALVES, TRAPS

22 **Integral Seat Valves**—Catalog No. 12-G6, 8 pages, contains valuable engineering data on this line of integral seat valves. Included are details of design, photographs and drawings of the various valves, dimensional tables and line drawings, and working pressure ratings. Described are integral seat valves and integral seat valves with body and bonnet a single unit. Edward Valves, Inc.

23 **Steam Traps**—This 4-page bulletin tells "how to select the right type of steam trap." An illustrated chart permits the reader to select the steam trap for his particular application. Large cross-sectional illustrations accompany the text. Such traps as the thermostatic steam traps, the inverted bucket steam trap, the float-thermostatic steam traps and the liquid expansion steam traps are discussed. The advantages of these traps, the special features and the recommendations are treated. Sarco Co., Inc.

24 **Steam Specialties**—Steam, air and blast traps, reducing valves, pump governors, and boiler feedwater controllers are described and illustrated in a series of six bulletins conveniently bound in a paper folder. Design features, specifications, and prices of all products are included. Two tables list the capacities of the steam traps and reducing valves. The C. E. Squires Co.

25 **Steam Traps**—How to select the right type of steam trap is explained in a 4-page Bulletin No. 1600. An illustrated chart permits the reader, at a glance, to select the right type of steam trap for his particular application. Features, advantages, and recommendations are listed for each type of trap. Sarco Co., Inc.

26 **Valve Bulletin**—Containied in this 12-page Bulletin No. 101A is information on lines of back pressure, exhaust relief, stop and check, relief and non-return valves, an air vent, a steam trap, and condensate traps. Complete engineering data includes diagrams of the units, price lists and dimensional tables. Davis Regulator Co.

27 **Valve Bulletin**—Contained in this 8-page Bulletin No. 101AA is information on lines of float boxes, internal float type units, float box with valve, float box with pilot valve and diaphragm motor valves. All items are well diagrammed and described with accompanying price lists. Davis Regulator Co.

28 **Safety and Relief Valves**—This is a 6-page condensed specifications bulletin No. 50 for safety and relief valves. It facilitates the prompt selection of these valves by means of a detailed index comprising two full pages. This listing gives all type numbers and other pertinent data, together with comparison numbers of other commonly used valves. Sizes, pressures and materials are indicated. Another two pages are devoted to a display of 31 separate valve sectional line illustrations. Farris Engineering Corp.

29 **Pump Valve**—Descriptions of various pump and silent check valves are included in this new bulletin of 4 pages. Simple drawings are used to explain the salient features of some valves, and cut-away photographs are included to show the different types of assembly. Explanations are given of the functions of each valve. Combination Pump Valve Co.

30 **Solenoid Valves** — Bulletin 51, 11 pages, describes and illustrates with drawings the various solenoid valves of this company. Individually, it describes the function of each valve and its method of operation. Price lists, with a breakdown of the various sizes of each separate type of solenoid valve, are also included. Davis Regulator Co.

31 **Control Valve**—A solenoid valve for the control of water, oil, steam, and air is described and illustrated in Folder No. 117. The method of operation is explained step by step and the company's three selections of piping methods are illustrated. Hays Mfg. Co.

32 **Safety Heads**—Catalogs 54 and A47 are combined in one catalog of 12 pages to give price lists of lines of safety heads and pressure vacuum vent valves. All price lists contain adequate engineering information. In addition there are a number of drawings showing the safety head flange extras in position. The catalog concludes with 4 pricing examples which state a problem and the method of pricing. Black, Sivalls & Bryson, Inc.

33 **Safety Heads — Chemical Feeders — Vent Valves**—Catalog A47, 8 pages, contains engineering data on this line of safety heads, chemical feeders and vent valves. The uses for safety heads is described, while photographs show typical models and three tables give bolted flange information, ratings and sizes and diaphragm material. The chemical feeders are described, photographed and detailed with specifications. A cut-away drawing shows a pressure-vacuum vent valve with its features. Included in the description of the valves are the specifications and operation. Black, Sivalls & Bryson, Inc.

MATERIAL HANDLING

34 **Conveyor Units**—Booklet No. 2175, 48 pages, is replete with engineering data, and valuable charts, tables and formulas to determine the conveyor unit size and proper operating speed for a given handling capacity and weight of material to be handled. Typical installations are shown and various conveyors are broken down to show component parts. There are many schematic layouts and typical path charts. Also included is a listing of the information needed for estimates. Link-Belt Co.

35 **Service Elevator**—A fast inter-floor transportation for use in buildings up to 200 ft high, is described and illustrated in this new 8-page Bulletin No. O6B6878. The elevators are designed to meet safety codes; diagrams showing safety measures to be considered are included in the bulletin. Typical applications are illustrated and a large full-page photo gives construction features. Allis-Chalmers Mfg. Co.

36 **Material Handling**—Systems for general industrial use, bulk material, warehousing, and special applications are described and illustrated in a new 16-page Bulletin No. 138. The company's 5-point plan which includes a complete plant survey, system design, proposal, supervised installation, and periodic check-up, is featured. Systems for handling barrels, kegs, drums, and rolls, as well as standard equipment for all systems, is also described and illustrated. Gifford-Wood Co.

37 **Material Handling Equipment**—Described in this 12-page catalog are such equipment as boiler house coal handling units, bulk handling machinery, bucket elevators, weigh larries and bunkers, package handling machines, and others. Innumerable photographs illustrate applications of the devices, while each item is fully described. Gifford-Wood Co.

PRIME MOVERS

38 **A-C Generators**—Vol. 8, No. 3a is a 16-page bulletin containing valuable information on a new "packaged" a-c generator. Included are tables showing how to select types of low-voltage electric service for the generator sets; the approximate power requirements for induction motors; and how to figure wire sizes. The various components in a control cabinet are diagramed. Typical installations are photographed. Included are diagrammatic indeces of generator switchgear for single, non-parallel, low-voltage generators, for paralleled, low-voltage generators and for paralleled high-voltage generators. There is also a discussion about how the oil and gas fields use generators. Electric Machinery Mfg. Co.

39 **Steam Turbines**—This is a fully illustrated, 8-page booklet on the solid rotor type steam turbine. It shows in detail the many engineering features of the company's product. Included are engineering drawings and dimensional data that should be useful in selecting the size and type of turbine needed for specific applications. Whiton Machine Co.

40 **Steam Turbine Units**—Current trends in power plant development with regard to standardized steam turbine units is discussed in this 16-page Bulletin No. 9. Carrying illustrations of models of six sizes of standardized units, as well as cross section drawings, the bulletin furnishes data on their ratings, capability and pressure and temperature limitations. It also lists the features and accessories to be furnished with the standardized turbine, and concludes with a description of the standardized units' excitation system. Allis-Chalmers Mfg. Co.

MISCELLANEOUS

41 **Motor and Generator Brushes**—In this excellent 42-page Catalog No. 25 is invaluable engineering data on a line of motor and generator brushes and carbon products. The catalog covers such material as manufacture, grade classification, fields of application and description of brush grades. The characteristics of brush grades and grade recommendation are included in two full-page tables. Brush definitions and standards are given. Shunt locations are explained as well as method of installation of brushes and how to order brushes. Included is a two-page brush data sheet along with brush definitions. A line of welding carbon products is also shown. Speer Carbon Co.

42 **Heating Coils**—Design and construction features, as well as complete specifications, for the standard, non-freeze, booster, and hot water heating coil are described and well illustrated in this new 48-page Catalog No. 348. Performance tables for steam capacities from 5 to 150 psi, entering air temp. from —30 to 80 F, and air velocities from 300 to 1500 ft per min for single and multiple coils; hot water coil capacities; steam capacity curves; air friction tables; and conversion factors for air friction and volume are given. Included in this informative booklet, which could serve as a handy reference manual, is a section devoted to an explanation of heating coil selection, piping arrangements, and suggestions for piping and installations. A pipe size table for steam and typical heating coil specifications are also included. Modine Mfg. Co.

43 **Floats**—This bulletin, 20 pages, describes in detail the complete line of copper, steel, Monel and stainless steel industrial floats offered by the company. It includes engineering data necessary to make volume and buoyancy calculations, together with diagrams of standard float connections used with float valves and liquid level controllers. Also pointed out is the manufacturer's service in the preparation of detailed recommendations to suit individual requirements, standard or special. Chicago Float Works, Inc.

44 **Pulverizers**—Contained in this 22-page bulletin is valuable information on a line of direct fired coal pulverizers for boiler firing. Their construction is completely described and illustrated. A 2-page typical installation drawing is shown, as well as many photographs of typical installations. Two drawings illustrate a round combination pulverized coal and gas burner and a round combination burner arranged for pulverized fuel or oil. The bulletin closes with large sectional drawings of two units. Erie City Iron Works.

45 **Aftercooling**—The benefits, principle and application of aftercooling, and a complete description of a line of aftercoolers are fully covered in this 16-page bulletin. Several pages illustrate the various aftercoolers with cross-sectional views

(Continued on page 138)

DESIGN
MANUFACTURE
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coal-handling systems
by G-W. These three basic systems for handling coal (and/or ashes), designed by G-W, have been adapted to varying conditions in boiler plants.
Let G-W do the entire job for you...design, manufacture, erection . . . shoulder all details . . . assume all responsibilities.
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ELEVATOR
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TOTAL AVAILABLE COAL STORAGE 550 TONS
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TRACK HOPPER
DRAG FEEDER
COAL RECLAIMING GATE AND CHUTE
COAL SCALE
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NEW EQUIPMENT NEWS

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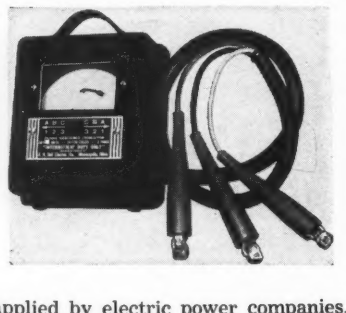
A Phase Rotation Indicator. Designed for use on 3 phase, 2 phase, 3 wire and 6 phase circuits 50 to 600 v, 25 to 120 cycles, a new phase rotation indicator can be



applied by electric power companies, industrial plant electricians and manufacturers of electrical equipment.

This instrument has been recommended for numerous operation, such as: "phasing out" new equipment, as transformer banks and alternators, for parallel operations; re-establishing disrupted service with power of proper phase sequence; installations of motors and condensers; establishing proper starting and running circuit of controllers; phasing power outlet in factories where portable equipment such as welders are used.

The instrument indicates phase sequence as established by the Electrical Engineering Society, by numercial, alphabetical, collar coding and CW-CCW methods. H. H. Sell Electric Co.

B Smoke Indicator. This photoelectric excess-smoke indicator introduces impersonal precision into combustion control. It is designed to give a continuous indication to the boiler room of the condition of the gases which are passing through the flue, signalling when either smoke or air are sufficiently excessive to

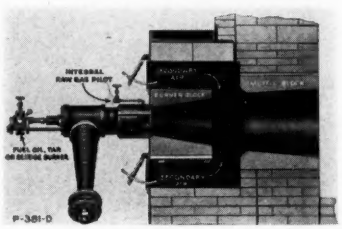
cause inefficient combustion or create a smoke nuisance and can be used in factories, utilities and other related establishments. Photoswitch Inc.

C Speed Reducers. A line of newly designed fan-cooled cone-drive speed reducers has been recently announced. The announcement reveals that the standard heavy-duty pinion-under cone-drive speed reducers were originally designed with applicability to fan cooling in mind. Thus, the basic units of the new fan-cooled reducers are identical with the non-fan-cooled models of this type. Standard cone-drive HU models already in service can be readily converted to fan cooling at any time, if desired, by the addition of the cone-drive fan and air-flow control shields.

The various reducers are available in standard ratios of 5, 10, 15, 20, 25, 30, 40, 50 and 60 to 1. The 5, 6 and 8 in. reducers are also available in a 70:1 standard ratio. All models are pinion under (FHU-heavy duty).

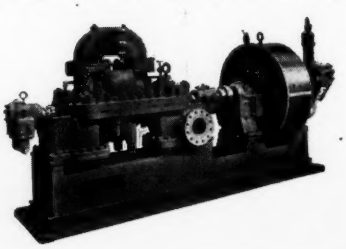
Removable shileds direct the fan impelled air over the finned lower portion of the speed reducer housing in such a manner that equalized air-flow is obtained at all points of the housing requiring cooling. The fins are so located and shaped as to guide the streams of air for maximum cooling efficiency. Michigan Tool Co.

D Combustion Unit. Production of a combination tandem block combustion unit has been recently announced. It is designed for dependability and so that it can economically perform with any grade of gaseous or liquid fuel. It is stated that it will operate with high combustion efficiency, a minimum of furnace



draft, low excess combustion air, and with a smokeless combustion on low settings. These units can be installed with steam plant boilers and superheaters, chemical retorts and kettles, and municipal incinerators and dryers. National Airoil Burner Co.

E High Pressure Pumps. Announcement has been made of a new line of six stage, type TH high pressure pumps for pressures up



FEBRUARY, 1948

POWER GENERATION

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for Power or Process piping . . . everything's in the CRANE line

Valves, fittings, or pipe line accessories . . . pipe or shop-fabricated piping units . . . whatever you need for new installations or replacements . . . most likely Crane supplies it. And with good, dependable quality in every single item.

On this water treating installation, for example, here's how the complete Crane line helps simplify the whole piping job. You specify from one catalog . . . get everything on one order to your local Crane Branch or Wholesaler. From start to finish, the job moves fast and smooth . . . with good piping performance assured. Because when you standardize on Crane materials, you get this 3-way advantage:

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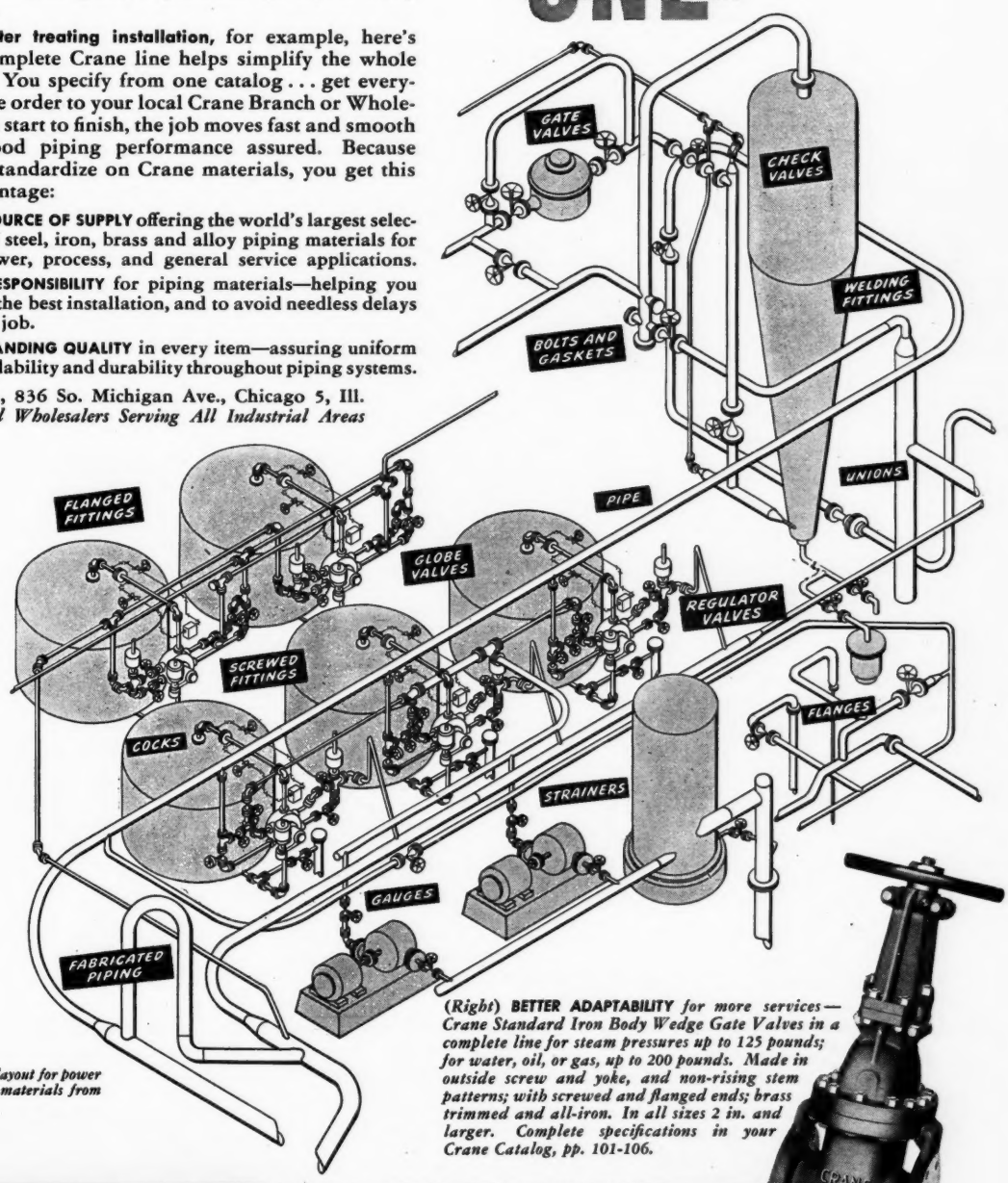

Water treating layout for power plant . . . piping materials from Crane.

(Right) **BETTER ADAPTABILITY** *for more services—Crane Standard Iron Body Wedge Gate Valves in a complete line for steam pressures up to 125 pounds; for water, oil, or gas, up to 200 pounds. Made in outside screw and yoke, and non-rising stem patterns; with screwed and flanged ends; brass trimmed and all-iron. In all sizes 2 in. and larger. Complete specifications in your Crane Catalog, pp. 101-106.*

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VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

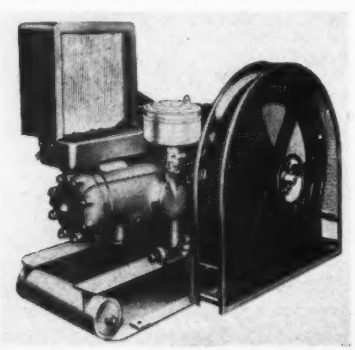
to 1200 psi. All water passages in these pumps are designed according to section and arrangement for smooth flow. Widely spaced supports located near horizontal center line help protect pump from misalignment due to temperature changes. Increased dependability, efficiency and life are said to result from these pumps being in radial balance as well as axial balance. By-passing between stages, the manufacturer states, is reduced to practical minimums by wide inter-stage seals which are stepped, forming semi-labyrinth. The pumps are designed to service boiler feed, pipe line, drainage, debarking and all high pressure hydraulic services. Warren Steam Pump Co., Inc.

F Diesel Compression Tester. A new Diesel cylinder compression tester to facilitate engine maintenance on Diesel-powered equipment, has recently been announced. It is supplied with a "universal" adapter which serves 54 types of Diesel engines.

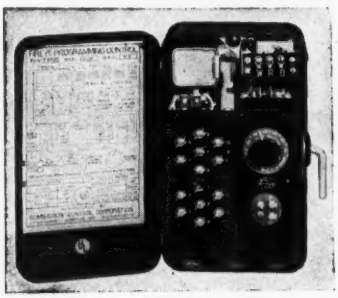
Simplicity of use is listed as one of the distinctive features of the instrument. The fuel injector is removed from the cylinder to be tested and the adapter of the compression tester is inserted into the injector opening. The adapter is held in place by the same means that is used for holding the fuel injector.

After attaching the tester, the engine is started and operated at either cranking or idling speed. The engine pressure is communicated to the dial gauge through a "cartridge-sealed" trapping device in the adapter, and the gauge pointer swings gradually to the maximum compression pressure. When the pointer has reached this position it remains stationary, permitting close, accurate reading. The air pressure in the gauge may then be released by depressing a push-button vent valve. The venting feature makes possible the taking of compression readings in quick succession. Bacharach Industrial Instrument Co.

G Heavy-Duty Engine. A new heavy-duty line of single cylinder horizontal two-cycle, multi-fuel engines has been announced. The first model, known as Lorain Type L, is now in production, and will operate on Diesel fuel, natural gas or butane. This engine has a rating of 10.7 hp at 300 rpm and 21.4 hp at 600 rpm. It has 7½ in. bore and 8 in. stroke with Timken bearings on crankshaft and cross shaft. A condenser type cooling system is provided and the announcement states that makeup water is negligible. White-Roth Machine Corp.



H Programming Control. Programming control Type 24-PJ8 is designed to provide automatic starting and programming control for commercial and industrial oil burning equipment. It is used with photo-electric flame failure scanner Type 45PH5 which protects the oil burning installation from the hazard of flame failure. The control automatically starts a burner in operation and programs a sequence of fuel valve opening, post-ignition time, priming, and scavenging.



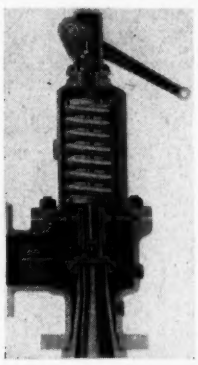
This programming control incorporates many unique design features. The timing cams are driven by a specially designed, high torque synchronous motor. The fuel valve delay and post-ignition periods can be easily set upon installation, and a calibrated dial clearly indicates the timing adjustment in seconds. All power handling contacts have snap action on opening and closing. Combustion Control Corp.

J Bell End Finned Tubes. Bell end finned tubes suitable for use in generator air coolers, after-coolers, economizers or other heat exchangers are now available in suitable sizes. Bell end facilitates retubing through large hole in tube sheet. Serrated fins help insure maximum heat transfer. They are being produced in admiralty tubing with copper fins solder bonded to tubing. Fintube Coil Corp.

K Boiler Control Method. A new method has been developed for the control of combustion in hog fuel-fired boilers by the brilliancy of the flame, furnace wall or fuel bed. This system has been developed so that the combustion of hog fuel can be satisfactorily controlled.

The new system utilizes a standard arrangement in that forced draft is controlled from steam pressure, induced draft is controlled from furnace draft, and fuel feed is controlled from steam flow; but differs in that the fuel feed is readjusted by brilliancy instead of by steam flow-air flow ratio. Brilliancy is measured by a photo-voltaic cell connected to a pyrotron pyrometer. In this new type of control a steam flow meter measuring boiler output proportions fuel feed to steam flow. It does this by setting up an air loading pressure which actuates the fuel feed control drive. The air loading pressure from the steam flow meter is combined with the air loading pressure set up by the brilliancy meter in an air relay to form an average air loading pressure. This is transmitted to the fuel feed control drive. The brightness of the flame is a test of the adequacy of combustion air, and the fuel feed is increased or decreased accordingly. Bailey Meter Co.

L Safety-Relief Valve. A new type of safety-relief valve has been designed for handling inlet pressures of 2000 psi, and temperatures up to 900 F and for handling corrosive liquids, vapors or gases. The new valve is made of cast steel with stainless steel trim. A high disc lift permits full capacity discharge. Nozzle body is of long neck construction to permit proper nozzle flow without restriction. The body is fully ribbed to absorb piping stresses.

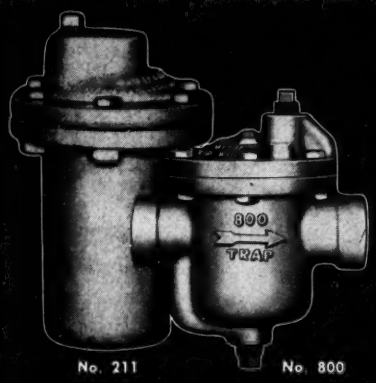


Stainless steel baffle plate restricts flow of vapors into spring chamber.

The combination of nozzle and inverted cone or secondary nozzle makes maximum use of the Kinetic energy of the discharge to effect, the high lift and full capacity, without need of adjustments. The maker states that this fact, coupled with a coefficient of flow efficiency established at 97½ means that a smaller valve can be used.

The new valve is available in sizes from 1½×2×6×8 in. Parts of valve are completely interchangeable. Farris Engineering Corp.

M Atmospheric Regulator. Furnace Engineers and users of low pressure gas in the in-



No. 211 No. 800

Above left — Armstrong bottom inlet—top outlet series trap.

Above right — Armstrong No. 800 side inlet—side outlet trap.

For Fuel Savings and Maximum Production

INSTALL AN INDIVIDUAL ARMSTRONG STEAM TRAP ON EACH UNIT

PROOF THAT ARMSTRONG TRAPS PAY DIVIDENDS:

MAINTENANCE IN 5 YEARS OF SERVICE FOR 20 [illegible] installed on press, tumbler boards, iron sets and [illegible]—*Gran Tintoreria* [illegible]

DRYING TIME CUT 25% [illegible] of Armstrong traps on [illegible] and vats. One trap [illegible] coil has given dependable service for 18 years—*[illegible] Baking Co., Elgin, Ill.*

MAINTENANCE REDUCTION and 20% FUEL SAVINGS with use of Armstrong [illegible]—*Eastern Box Co., [illegible]*

UNIFORM TEMPERATURE [illegible] and maintenance after installation of [illegible] traps.—*Zeidler Floral [illegible], Indiana.*

WHY UNIT TRAPPING IS ESSENTIAL: If you try to drain condensate from more than one steam-consuming unit with the same trap, sluggish heating and low temperatures will almost always result. This is because no two units condense steam at the same rate. The pressure will be lowest in the unit condensing steam the fastest. Condensate from the higher pressure unit will back up into the lower pressure unit (or close the check valve), temporarily blocking off its drainage. This prevents escape of air and condensate, lowers the machine temperature and wastes fuel. However, the use of a separate trap on each unit permits individual operation without any effect from different condensing rates. You get maximum temperatures and maximum production.

WHY *ARMSTRONGS* ARE BEST FOR UNIT TRAPPING: They not only discharge condensate as fast as it accumulates, but they discharge air as well. This is essential to fast heating and uniform high temperatures. Furthermore, you don't have to be afraid of increasing the number of traps in your plant because Armstrongs seldom need attention. They won't clog or stick; dirt is swirled right through; the chrome steel valve and seat and corrosion-resistant stainless interior stand up in constant service for years and years.

THE ARMSTRONG STEAM TRAP BOOK gives complete data necessary for selection, installation and maintenance of Armstrong traps. Send for a copy.

ARMSTRONG MACHINE WORKS
810 Maple Street • Three Rivers, Michigan

ARMSTRONG *Inverted Bucket* STEAM TRAPS

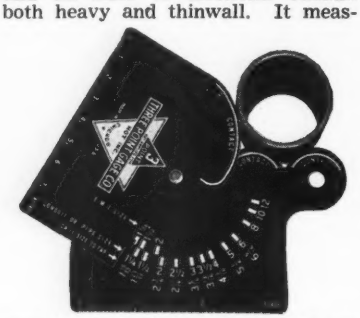
No. 3 of a series of advertisements devoted to improving efficiency through better trapping.

dustrial heating field will be interested in the new soft-seat atmospheric regulator. It features tight shut-off when the demand for gas flow ceases by incorporating a soft synthetic rubberized fabric facing on the regulator valve head. Users will find the tight shutoff feature quite advantageous in that close control can be realized at low gas flow.

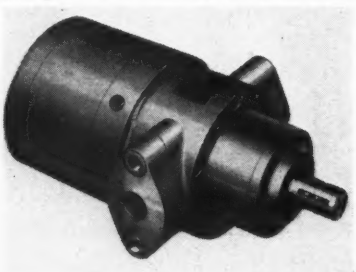
The regulator furnishes gas at atmospheric pressure and requires as a supply, gas pressure of from 2 to 16 ounces. Although it was designed, as indicated by its name, especially for supplying atmospheric gas to premix systems, single valve control also can be had with nozzle-mix systems by connecting the vent on the regulator into the line supplying air to the burner on the downstream side of the control valve. The regulator responds quickly to very slight changes in impulse line pressure. Both premix and nozzle-mix systems are assured proportional air-gas ratios over the entire regulator capacity range.

Made in sizes ¾, 1, 1¼, 1½, 2, 2½ and 3 in., the atmospheric regulators have capacities ranging up to 16,000 cu ft of natural gas per hour or 19,000 cfh mfd gas. Shipments can be made from stock. North American Mfg. Co.

N Pipe Gage. A new pipe gage will measure instantaneously all sizes of pipe from ⅛ to 12 in., and all sizes of electrical conduit both heavy and thinwall. It measures by determining the outside arc at three points of contact, and by placing the two fixed contact points of one plate against the outer contour of the pipe or conduit and sliding the second or movable plate until it makes a third contact. The markers on the face of the gage then show accurately the size of the pipe or conduit and also the correct drill size for tapping. The list price is $2.00. Three Point Industries.



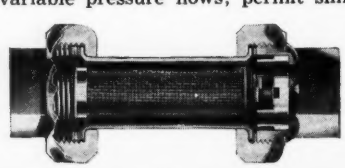
O Hydraulic Fluid Pump. This new high pressure, high volume hydraulic fluid pump of the axial piston, constant displacement type is rated at 3500 psi for continuous heavy duty operation, although higher pressure is said to be permissible for intermittent operation. It is designed to provide combined power and speed of operation. The three models handle volumes of 6, 17 and 32 gpm, respectively, at 1200 rpm, maintaining volumetric efficiencies of not less than 95 per cent.



Outstanding features include quiet operation at all pressures; high pressure, high volume, constant displacement design; minimum parts; compact construction; elimination of all thrust bearings; unique two-piece shaft which absorbs deflection and minimizes bearing wear; and axial piston design which provides for long trouble-free service. Two types of mounting, foot and flange, in addition to the face mounting of the pump provide a variety of methods for the installation of the pumps. Denison Engineering Co.

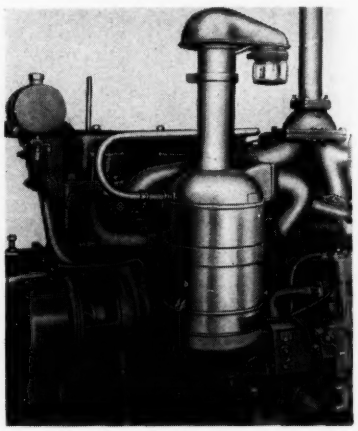
P Liquid Filter. For full flow filtering, a new bag type liquid filter has been developed. It may be used for fuel or lubricating oils—straight mineral or heavy duty additive oils, and will not remove or affect the additives. The bag style filter is made in seven sizes from ¼ to 400 gpm filtering capacities depending upon the viscosity and pressure. There is a built-in relief valve for safety in case cleaning is neglected or the oil is very cold and viscous upon starting. If such protection is provided, in the outside connecting piping, as is the case of fuel oil systems, then the built-in relief valve is eliminated. The over-all height of the filter is 24¼ in., diameter 7 in., net weight 24 lb, inlet and outlet ½ ips. Wm. W. Nugent & Co., Inc.

Q Strainer and Flow Regulator. This new combination strainer and flow regulator can be used on water, oil, gas and air. The regulator is designed to automatically measure predetermined amount of flow regardless of variable pressures; subdue excessive pressure "hammer"; automatically absorb variable pressure flows; permit simple timing mechanism for measured quantities.



The control has bronze couplings, copper tube body, Monel metal strainer, non-corrosive orifice plate, molded rubber diaphragm and asbestos neoprene gaskets, and comes with three selections of piping methods: female iron pipe, flared copper tube and solder connection. Hays Mfg. Co.

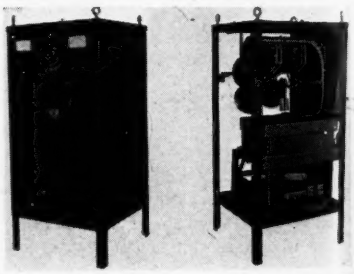
R Dual-Fuel Attachment. A dual-fuel attachment, designed for service with the manufacturer's Diesel D13000 engine, has been recently announced. The new unit, which can be installed at the factory, is of particular interest to engine users in, or near, gas producing areas where pipeline gas can usually be obtained at low cost. In industrial areas, where "dump gas" rates prevail during the summer months, this low cost gas can be used, changing back to full Diesel operation for the balance of the year.



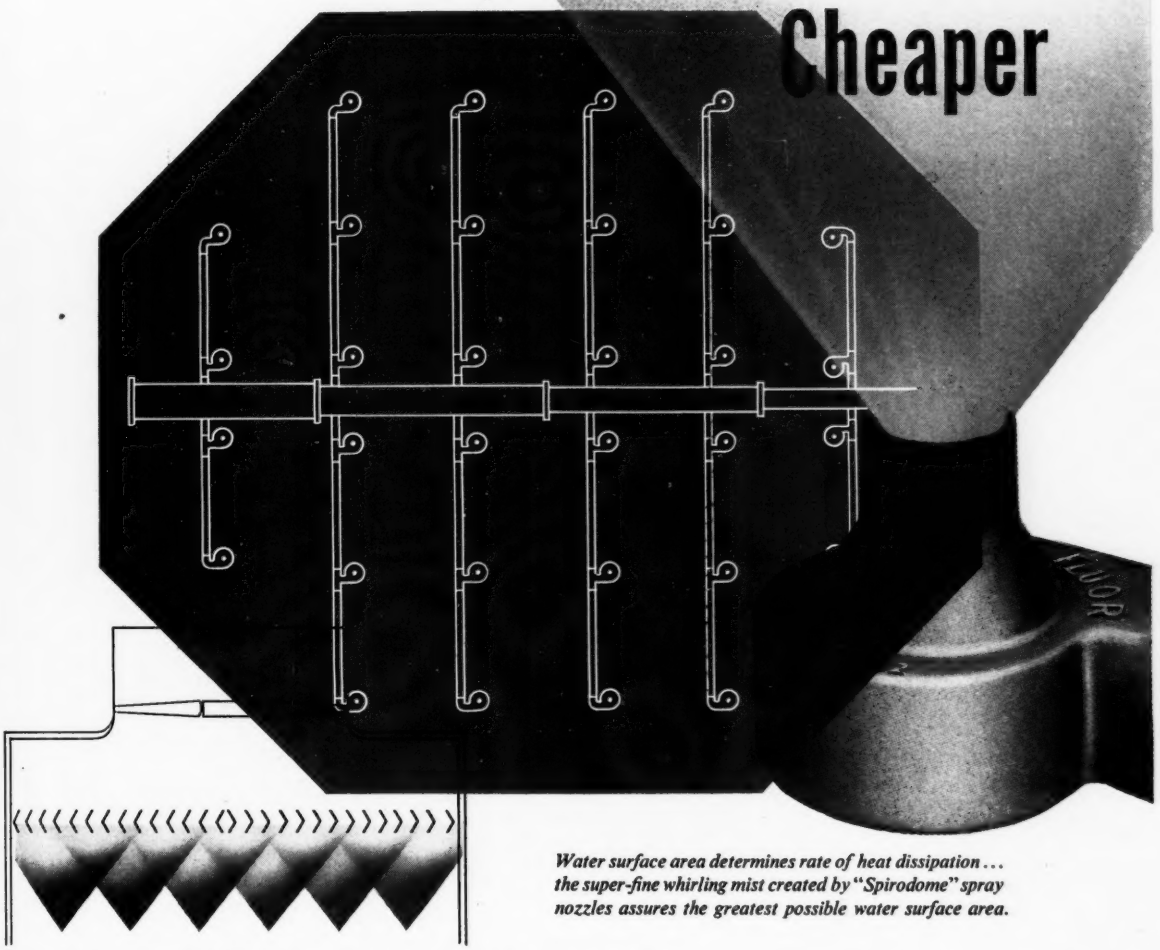
The attachment consists of special precombustion chambers, modified fuel injection pumps for precise metering of minute quantities of Diesel fuel, a special governor control assembly for interconnected fuel injection pump and gas throttle valve and the necessary gas lines and pressure regulators. Caterpillar Tractor Co.

S Rectifier. A new line of low voltage high current rectifiers is now available for operation from 220 or 440 v three phase a-c power lines. D-c output voltage can be varied from 0 to 6 v, with a capacity of 600 amp, or from 0 to 12 v with a capacity of 300 amp. Although primarily intended for use in electroplating and electrolytic cleaning, these rectifiers provide an ideal source of power for production testing, and running in, of 6 v and 12 v d-c motors, etc.

The new rectifiers feature thoroughly sealed selenium rectifier elements; heavy duty variable voltage transformer, providing stepless con-



THOROUGH AIR-WATER MIXTURE = Colder Water Cheaper



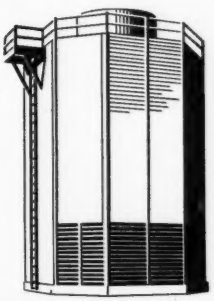
Water surface area determines rate of heat dissipation... the super-fine whirling mist created by "Spirodome" spray nozzles assures the greatest possible water surface area.

Cheaper? Yes, and here's why: The upspray distributing system in the Fluor "Counterflo" induced draft cooling tower, which incorporates the patented "Spirodome" Spray Nozzles, adds 8 or 9 feet of *unseen* cooling tower height. Here's how:

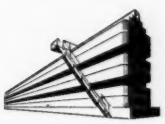
Water is sprayed 6 to 8 feet up into a spray chamber, where the drops are broken up into minute particles, and where the great heat load is flashed off before the drops even reach the first deck. Therefore the function of the decking is not to release the great bulk of the heat, but rather to cool the water to as close to wet bulb temperature as possible.

This system is a "must" where hot water is to be cooled, since the upper portion of the tower is at least twice as effective as the same tower with the usual flume and splash plate system.

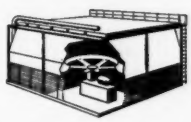
Yes...Fifty years' experience proves Fluor Cooling Towers will, year in and year out, deliver colder water cheaper.



Fluor "Counterflo" induced draft cooling towers, prefabricated in mass production, are available in multiple or single units in any required size or height.



Fluor areator atmospheric cooling towers are recommended where conditions make this type most practical.



The Fluor Fin-Fan cooling unit has a wide, economical range of utility throughout industry.

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SERVICES : *Designers and Constructors of Refinery, Chemical and Natural Gas Processing Units*

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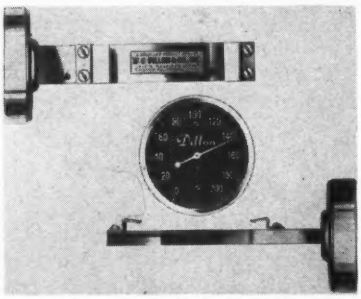
trol over output voltages, from zero to maximum setting; and each unit is complete and concludes large 4½ in. ammeter and voltmeter and protection against overloads and failure of ventilation system. Priced at $690.00. Mellaphone Electronic Rectifier Co., Inc.

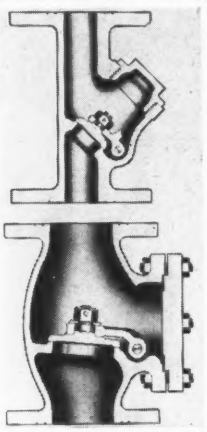
T Dial Type Thermometer. This new instrument has been designed to clamp primarily onto such flat or rectangular surfaces as power bus-bars, switch blades, en-



gine blocks, water jackets, etc. With this flat stem design, the heat element goes down snugly against the object under test and presents a wide heat absorbing area.

These new thermometers can be supplied in flat stems of varying widths, thicknesses and lengths and are available in a wide range of metals. The capacities are standard. W. C. Dillon & Co., Inc.

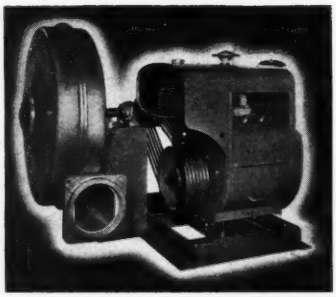
U Swing Check Valves. New lines of corrosion-resistant swing-check valves in sizes ⅛ in. to 6 in. with screwed or flanged ends,



and in sizes 2½, 3, 4 and 6 in. with flanged ends only, both 18-8 Mo alloy steel and Monel metal, have been introduced. These new checks are designed for the moderate pressures and temperatures usually encountered in piping corrosive fluids. They are recommended for liquid or gas working pressures up to 150 lb and fora maximum temperature of 350 F.

In the sizes ⅛ to 2 in., the body is made in a Y-pattern, and the cap is on the same center line as the seat opening. In the 2½, 3, 4 and 6 in. size, the body is the straightway type, with the seat face at only a slight angle from vertical. When so ordered, the latter valves can be furnished with outside lever and weight. Crane Co.

V Internal Combustion Engine. This manufacturer is expanding its regular line of turbo blowers to include an internal combustion engine powered unit. It is

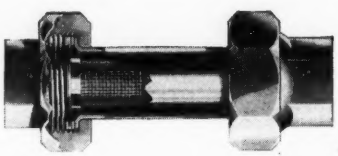


designed primarily for emergencies caused by power failures. The unit is compact, yet the air-cooled engine, v-belt drives and impeller jackshaft are all very accessible for greasing, cleaning or adjusting.

For combustion systems using oil burners, an oil pump may be had with the unit which is built in as an integral part. The entire combustion system is thus self-contained. The welded steel base is designed to permit belt tension adjustments without fear of misalignment. A governor on the engine assures a steady speed for the turbo blower and the oil pump. A constant air and oil pressure results.

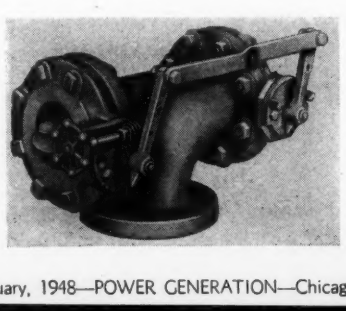
The unit lends itself well to applications requiring portability, such as scove kilns in brick yards. North American Mfg. Co.

W Strainer. A new strainer that can be used for either water, steam, oil, air or gas has been announced. The strainer is designed to offer clean uninterrupted flow, no



restricted passages, no flow offset, accessibility from all directions for cleaning, large screen area related to size, entire unit removable to clean, performance as a coupling unit, copper tube body, bronze couplings and Monel metal. It is being sold with three selections of piping methods: female iron pipe, flared copper tube, and solder connection. Hays Mfg. Co.

X Butterfly Valve. A simple butterfly valve has been developed for three-way operation. This valve consists of two butterfly valves and a tee, with the valves interlocked so that the closing of one vane opens the other in any operation.



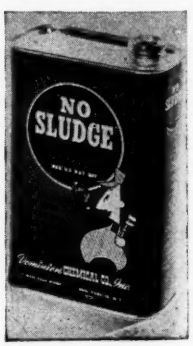
The valve may be lever or hand wheel operated. For larger pipe sizes, roller chain and sprocket connections are arranged so that one hand wheel or chain wheel closes one vane while opening the other. Automatic operation can readily be applied. The valve is available from 4 to 60 in., American Standard Pipe Flange Sizes, in case iron or special alloys. They can be built for pressures to 100 psi and temperatures to 1800 F. W. S. Rockwell Co.

Y Refractory Coating. A new refractory coating has been developed for use as an insulative coating for preventing spalling action, resisting heat penetration and decreasing carbon, slag and clinker

adherence in fire boxes, furnaces and crucibles. It can be applied by either brush or spray.

This coating forms a semi-glazed protective monolithic wall of from 8.5 to 9 hardness (Diamond is 10-Mohs scale) between fire and the fire brick, and is stated to be impervious to heats up to 3390 F, and to withstand the destructive effects of flame impingement and abrasion. Whitman Co.

Z Fuel Oil Treatment. A new fuel oil treatment, "No-Sludge", is now available in 1 qt cans. It is made for use in industrial plants as a fuel oil additive in all grades of oil from kerosene to Bunker C. It is stated that it removes and prevents sludge, eliminates condensation and seepage, improves combustion, reduces soot and carbon, and prolongs the life of equipment.



In Diesel engines this treatment is said to reduce surface tension of oil and improves atomization, which helps complete combustion, and also lessens the deposit of carbon on piston and rings.

One quart can treats 2000 gal of oil. Dominion Chemical Co.

AA Selenium Rectifier. A selenium rectifier that is designed to maintain constant voltage

You Can See for Yourself . . .

WHY the Foster 38-SV Safety Valve is ESPECIALLY SUITABLE FOR

HIGH PRESSURES HIGH TEMPERATURES

Pressures up to 3000 pounds and temperatures of 1200° F. are easily handled by the Foster Type 38-SV Super-Jet Safety Valve—it was designed especially for just these exacting requirements! It's no mere "beefed-up" low-pressure valve—rather it's a basic new design for high-pressure service.

Only the Foster 38-SV Safety Valve gives you all these advantages:

1 . . . ***Exceptional steam economy*** because . . . it reseats as low as 1% below popping pressure . . . reseating is positive; without pounding or chatter . . . blowdown is adjustable from 8% down to 1%.

2 . . . ***Unaffected by temperature changes*** because . . . frame rod construction makes crawl negligible . . . deflector protects spring and rods from escaping steam.

3 . . . ***Maximum protection*** because . . . full opening is practically instantaneous . . . full rated nozzle capacity is available at popping pressure . . . once set under operating conditions, its popping point is constant.

4 . . . ***Positive reseating*** because . . . floating disc design . . . steam-centered piston . . . permanently flat seats.

Specify the Foster 38-SV Super-Jet Safety Valve for the finest in high-pressure protection!

Complete details of the Foster 38-SV Super-Jet Safety Valve, for pressures up to 3000 pounds and temperatures up to 1200° F., are given in Bulletin 25. Write for it today!

FOSTER ENGINEERING Company

PRESSURE REGULATORS...RELIEF AND BACK PRESSURE VALVES...AUTOMATIC STOP AND CHECK VALVES...ALTITUDE VALVES...DAMPER REGULATORS...FAN ENGINE REGULATORS... PUMP GOVERNORS...TEMPERATURE REGULATORS...LIQUID LEVEL CONTROLLERS...FLOAT AND LEVER BALANCED VALVES...NON-RETURN AND TRIPLE DUTY VALVES...VACUUM REGULATORS OR BREAKERS...SIGHT FLOW BOXES...STRAINERS...SAFETY VALVES...SIRENS

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regardless of the changing amounts of current drawn from it has been announced. The rectifier is constructed to handle large gangs of low voltage d-c magnets in varying loads of from 0 to 20 amps with no appreciable variance in voltage. The d-c voltage control, it is said, will maintain or increase the starting voltage until the full amperage has been drawn from the rectifier, in contrast to the ordinary rectifier in which the voltage drops as the current is increased.

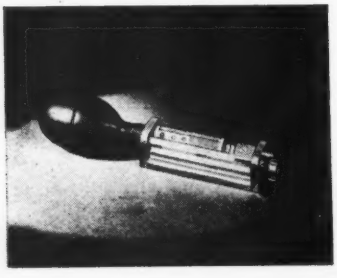
The rectifier itself is a full-wave bridge type suitable for any a-c frequency and a line voltage of 115 to 230. The pulsating d-c is filtered about 25 per cent, but a smoother current can be supplied if necessary. The rectifier occupies about 1 cu ft of space. The manufacturer states that this rectifier has many potential uses in the industrial field. La Marche Mfg. Co.

BB Voltage Tester. A new voltage tester tests continuity of circuits (a-c or d-c), 110 to 550 v a-c 110 to 600 v d-c, blown fuses, grounded side of line, grounded side of motor or appliance, excessive leakage to ground, frequency (25 or 60 c) and d-c polarity.

Indications are by a solenoid indicator and a neon test lamp, each operating independently of the other. Securely anchored 2 ft leads are brought out through the top of the case.

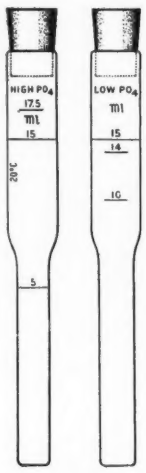
The scale is calibrated from 110 to 600 v; the overall length is 6 in.; leads are 2 ft long; test prod handles are 4 in. long; test prods are 2 in. Ideal Industries, Inc.

CC Carbon Monoxide Tester. A new carbon monoxide tester, utilizing tubes developed by the National Bureau of Standards, is designed to determine the presence of deadly carbon monoxide concentrations in air. Requiring no special training to use, the tester is said to be capable of indicating the presence of carbon monoxide from 0.001 to 0.10 per cent by volume in air.



The nucleus of the instrument is a detector tube containing a yellow silica gel, impregnated with a complex silico-molybdate compound and catalyzed by means of palladium sulfate. In use, the sealed ends of the tube are broken in the convenient tube-breaker and the tube inserted into the instrument tube-holder. A sample of the air is aspirated through the tube by squeezing the bulb of the instrument. If the air sample contains carbon monoxide when it is drawn through the tube, the yellow indicating chemical turns varying shades of green, directly proportional to the CO concentration; the degree of discoloration of the gel is then compared with the instrument's integral revolving color scale for quick reading. Mine Safety Appliances Co.

DD Water Analysis. A new combination phosphate mixing and testing tube has been developed for use in water analysis. It is designed to eliminate the need for a funnel; the top epining permitting filtration of the water sample direct into the tube. This opening also helps prevent damage that may be caused by unavoidale spillage of stannous chloride on wearing apparel, and helps eliminate need for pouring of molybdate reagent or stannous chloride into one tube, and the many repourings into another test tube. Tru-Test Laboratories, Inc.

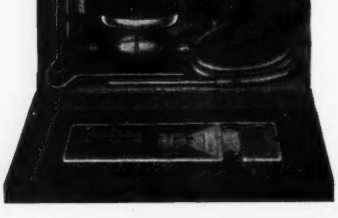


EE Combustion - Testing Kit. A new combustion-testing kit, containing a carbon dioxide indicator, a draft gauge and a tempoint stack thermometer, has been recently announced.

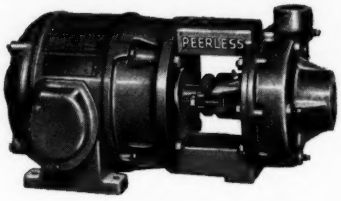
The carbon dioxide test is made by pumping flue gas into the instrument by stroking the rubber bulb. The sampling hose is then released, the instrument is turned bottom-side up and back again to mix the gas sample with carbon dioxide absorbing fluid contained in the bottom of the instrument. Absorption of carbon dioxide draws the absorbing fluid up into the center tube of the indicator. The level of the fluid indicates the percentage of the carbon dioxide which is read from the scale at the right side of the center tube.

The draft gauge is available in three standard ranges: 0.25 in. updraft to 0.05 in. down-draft; 0 to 1.0 in. water draft and 0 to 25 mm water. It is supplied with 9 ft of rubber tubing.

The range of the tempoint stack thermometer is 100 to 950 F in 10 deg divisions. The dial case is sealed against dust and moisture. Bacharach Industrial Instrument Co.



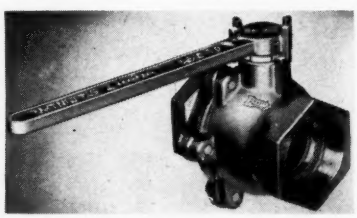
FF Centrifugal Pump. A general utility centrifugal pump, with power drives from fractional to 20 hp, has been recently introduced. It is a single stage, end suction and vertically split case centrifugal pump, and is being manufactured in two types, both of which are



capable of moving water and other liquids in capacities up to 1000 gpm against heads up to 270 ft.

Type PE is an integrally coupled, compact electric unit in which pump and driving motor are anchored on the motor footing. Type PB is a belt driven unit with the iron frame and bearing mounts supporting the various pump sizes integrally cast. The latter type pump is either keyed to a V or flat belt pulley, as desired, or directly connected to a standard horizontal electric motor by means of a pin type flexible coupling. Peerless Pump Div., Food Machinery Corp.

GG Ball Type Valve. Designed with a full round port area which should not permit the shape of the fluid stream to change, this new valve is made in bronze with screwed ends in all pipe sizes from



½ to 2 in. for 150 psi working pressure. It is recommended for use in handling water, air carbon dioxide, nitrogen and other gases, paraffin and asphalt base petroleum and also alcohol, paper fluids and many other types of liquids and gases. Rockwood Sprinkler Co.

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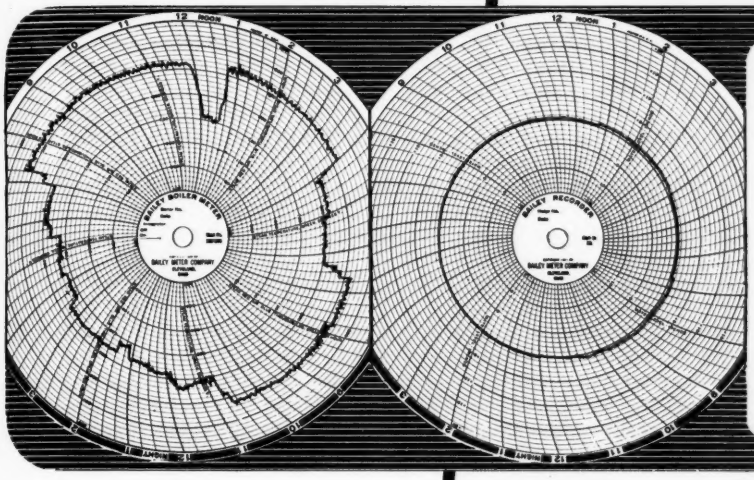
5 YEARS IN SERVICE

CONTINUES TO *Hold*



BOILERS
Combustion Engineering 3-Drum

MAXIMUM CAPACITY
275,000 pounds per hour

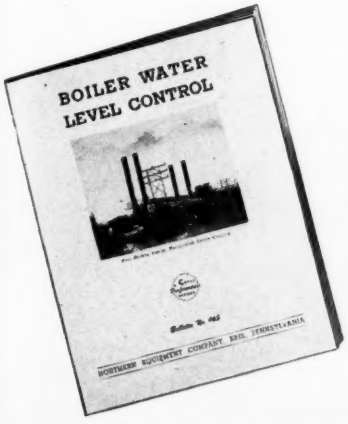
STEAM CONDITIONS
1265 psi and 900 degrees F. at the superheater outlet

LEVEL CONTROL
COPES Flowmatic Type R-O

WATER LEVEL WITHIN ± ½ INCH ON 1265-PSI, 900° F. BOILER

If you want close boiler water level control, consider these charts. They show level held within plus-or-minus one-half inch over a load range of 110,000 pounds per hour. They were recorded five years after COPES Flowmatic was placed in service. During this period, the only servicing needed was the routine care by plant personnel. Depend on COPES!

NORTHERN EQUIPMENT COMPANY
282 GROVE DRIVE, ERIE, PENNSYLVANIA
BRANCH PLANTS in Canada, England, France and Austria
Representatives Everywhere



Write for Performance Report Bulletin 465 on this important utility plant.

COPES

Headquarters for . . .

Boiler Feed Water Control . . . Excess or Constant Pressure Control, Steam or Water . . . Liquid Level Control . . . Balanced Valves . . . Desuperheaters . . . Boiler Steam Temperature Control . . . Hi-Low Water Alarms.

The popularity of the Yarway Liquid Level Indicator as a dependable boiler room instrument for instant, accurate, eye-level readings of overhead water levels, has led to a demand for supplementary *remote* signal devices *operated from the indicator.*

The new Yarway Control Unit with its remote light or horn Hi-Lo Alarm Signals, now answers that demand.

These signals installed at one or more remote points where a check in water level is desirable, provide both high level and low level alarms, within the full operating range of the Yarway indicator.

Light alarms show red for high or low levels—green for normal level. Horn signal has two vibrating horns of different tones, or a single horn for both high and low levels.

For complete details on this latest addition to the Yarway line of dependable steam plant equipment, write for Bulletin WG-1822.

YARNALL-WARING COMPANY
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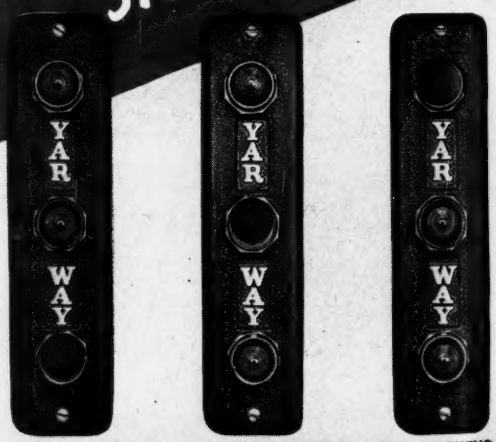
NEW!

WITH YARWAY REMOTE BOILER WATER LEVEL INDICATORS . . . AUDIBLE AND VISIBLE REMOTE SIGNAL ALARMS

YARWAY REMOTE HI-LO ALARM SIGNAL HORNS.



YARWAY REMOTE HI-LO ALARM SIGNAL LIGHT, SHOWING LOW LEVEL, NORMAL OPERATION AND HIGH LEVEL.

YARWAY REMOTE LIQUID LEVEL INDICATOR

WHAT LEADERS SAY

The Strength of America

By DAVID E. LILIENTHAL

EACH day all over the world, we, the people of the United States, are given a physical and mental appraisal by the people of other lands. Some of this "going over" is so palpably false, so coarse and downright mean that it shocks most of us; for very few of us are given to such extremely bad manners when we talk about other peoples.

But whether the looking over we are getting around the world is sincere and temperate—as it often is—or deliberately false, and incredibly mean—as much of it is—the justification for this constant appraisal of America is clear enough. For we no longer say: "Our way is good enough for us; please go away and don't bother us with your problems." Upon a world-wide stage, we stand today as the exemplars and the active protagonists of certain heroic principles of human life, about which we feel so deeply that we are prepared to stake everything upon keeping them alive and flourishing. We assert that the principles by which we live are basically opposed to, and demonstrably superior to, those modern versions of tyranny over men that first enslaved and then destroyed the German and the Japanese people. and that now threaten the peoples of all Europe and of Asia.

If I understand the essence of our evolving foreign policy, it is based largely upon what be believe to be the peculiar merits and the superior qualities of our domestic policy, that is, our way of living together here at home. The anxious peoples of the world are bedeviled and often confused by many voices in their own lands, telling them just what America is like, what our motives are. The confusion abroad is natural enough. **But we should take care that we ourselves do not get confused about the sources of our strength, about what it is that makes America strong and that will keep her strong.**

What is this source and this foundation of our American strength? The answer most commonly heard is: our economic system. This "system" is variously referred to as the capitalist system, or democratic capitalism, or the system of free enterprise, or some similar expression.

The central role of free, competitive, private enterprise in the life of America can hardly be exaggerated. But neither this nor any other answer in economic terms can explain our basic vitality.

The basic source of the strength of American civilization does not lie in an "economic system." The wellsprings of our vitality are not economic. They go deeper still: they are ethical and spiritual. Our society in America is founded not upon the cold and bloodless "economic man" of the Marxist, but upon a faith in man as an end in himself. We believe in man.

We believe in men not merely as production units, but as the children of God. We believe that the purpose of our society is not primarily to assure the "safety of the State" but to safeguard human dignity and the freedom of the individual. We are a people who have built upon a faith in the spirit of man, who conceive that the development and happiness of the individual is the purpose and goal of American life. I judge that we are not ready to "trade in" this luminous concept of a people's purpose for the notion that the America of the Bill of Rights, of Walt Whitman and Justice Holmes and Abraham Lincoln, is simply a highly productive economic system.

What we have, actually, is not a system at all, but almost its opposite —that is, a society of the greatest imaginable diversity and flexibility, taking things as they come, deciding how to handle situations by the facts of each situation itself—"doing what comes naturally." The only way in which it can be said to be a "system" is to say that our "system" is to have no system.

We have ethical guide lines in this country. We have developed rather highly a sense of what is right and what is wrong, of what is fair and decent, and what is just crude use of arbitrary power. A cynical labor leader or business giant, a cynical politician or public official — those who conceive of American society as nothing more than a jungle in which the most ruthless prevails—we may not catch on to such men right away. We can be fooled for a time by a mask of pretense. Sometimes we are slow to repudiate cynical disregard of our democratic faith—but that faith is always there, the foundation of our buying and selling, our hiring and firing, our political and financial institutions. No factory can be operated, not a carload of wheat sold, not a labor dispute negotiated, not an election held, that these ethical, legally unenforceable precepts are not part of the transaction.

I do not see how our kind of society could flourish in any other way. A highly interdependent country, one capable of producing more than $150,000,000,000 worth of goods a

(Continued on page 57)

David E. Lilienthal was appointed Chairman of the United States Atomic Energy Commission by President Truman on October 28, 1946. He executed the oath of office on November 1, and has actively served as Chairman of the Commission since that date.

He was born in Morton, Ill., July 8, 1899; spent his boyhood and youth in Valparaiso and Michigan City, northern Indiana; was graduated at DePauw University, Greencastle, Ind., 1920. He attended the Harvard Law School and was awarded a Bachelor of Laws Degree by that institution in 1923, and an honorary Doctor of Laws Degree by DePauw University in 1945.

From 1923 to 1931, Mr. Lilienthal practiced law in Chicago. In 1931, Governor Phillip La Follette appointed him a member of the Wisconsin Public Service Commission, where he served until 1933, when he was appointed a director of the newly created Tennessee Valley Authority.

He was reappointed to the Board of Directors for a nine-year term in 1936 and in 1941 was appointed chairman of the board.

He served as chairman of the Board of Consultants appointed in 1946 to report on the status of atomic energy. The Board studied the problem and on March 16, 1946, submitted its report to the Secretary of State's Committee. Referred to as the Acheson-Lilienthal Report, this was described by its authors as a "place to begin, a foundation on which to build." As such it served as basic material in the development of the subsequent official American proposal presented by Bernard Baruch. It has been fully presented in previous issues of POWER PLANT ENGINEERING. Recipient of the 1945 Progressive Farmer Award for services to agriculture, Mr. Lilienthal has also received the Catholic Committee of the South Award for 1946. He is the author of "TVA, Democracy on the March." He is a member of Delta Upsilon, Phi Beta Kappa, and Sigma Delta Chi.

The above material is taken from remarks made by Mr. Lilienthal before the New York Herald-Tribune Forum in New York, October, 1947.

University of Illinois Growth Requires Abb

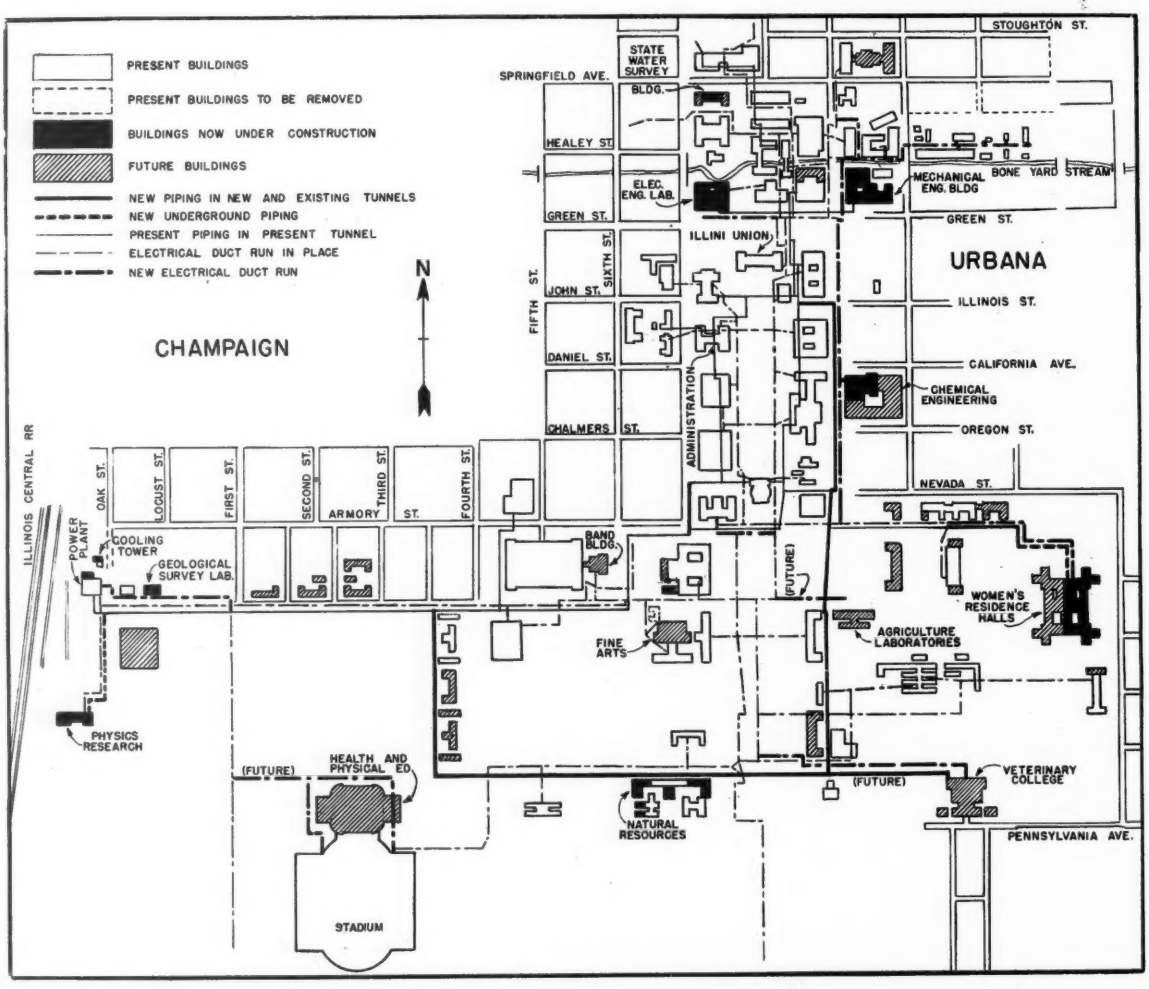


Fig. 1. Simplified map of University of Illinois, Urbana Campus, showing new buildings now under construction and extension of underground steam and electric lines to serve them. When these are completed, there will be approximately 10 miles of underground tunnels carrying steam lines

THE UNIVERSITY OF ILLINOIS at Urbana, Illinois, is now in the midst of a building program to enlarge and improve its facilities for handling its growing student enrollment and also for enlarging its educational scope and its research work.

To supply steam and power to the new buildings, research laboratories and other facilities now under construction, the University's power plant is being expanded by installation of a fourth steam generating unit and a third turbine generator unit. In addition, an extensive program is under way to extend the underground steam and electrical distribution systems as required to meet the new demands. Details of these additions are given below.

The University's power plant was built in 1940 at the West end of the Urbana Campus, Fig. 1, replacing the old plant at the north end, for reasons discussed below. This plant was named the Abbott Power Station in honor of W. L. Abbott, famous power engineer, who had been chief operating engineer of Commonwealth Edison Co. for 50 years, had been intimately associated with outstanding power plant developments during that time, and had served for 18 years on the University's board of trustees, 14 of them as its president.

The power plant built in 1940 contained three 80,000-lb-per-hr horizontal cross-drum straight tube boilers, generating steam at 325 psi, 650 F for two 3000-kw steam turbine generator units, which supplied extraction and exhaust steam at pressures varying between 10 and 70 psi from summer to peak winter heating load. Live steam is sent directly from the boilers through pressure reducing and desuperheating stations into the steam distribution mains at 150 psi, 450 F to serve process requirements on the campus. The generators supplied electric power at 4160 v to the electrical distribution system. The power plant building was designed to house three steam generating units and three turbine generators, although only two turbine generators were installed in 1940.

The present extension expands the boiler house part of the plant to house one more boiler, while the third turbine generator will soon be installed in the space originally provided for it. Work on the boiler house extension is now under way.

In addition, construction of about 3 miles of additional steam distribu-

Abbott Power Station Expansion

By GORDON V. CARLSON
Superintendent of Utilities,
Physical Plant Department,
University of Illinois

As told to CHESTER R. EARLE,
Managing Editor, Power Generation

Increase in post-war enrollment and enlarged scope of educational and research activities at University of Illinois, Urbana, Illinois, require new buildings now, others later . . . More steam and electric power required for these enlarged facilities . . . New 80,000-lb-per-hr stoker-fired boiler and 3000-kw condensing extraction turbine being added in Abbott Power Station as planned in original design . . . Steam distribution tunnels and electrical conduit systems being extended to serve new buildings . . . Discussion of factors determining design of original plant and present extension . . . Power supply for betatron requires very close frequency control on turbines . . . Expected load of at least 10,000-kw by 1955, or even more, will require another turbine generator . . . Details of plant performance

tion tunnels and underground electrical ducts is under way, to extend these services to the new buildings, as in Fig. 1. Full details of the new power plant equipment are listed on page 56, while the drawings show the general arrangement of the equipment. The heat balance diagram, Fig. 4, shows the connections of the plant equipment and the heat balance for conditions expected by 1955.

Basis on which the Abbott Power Station was originally designed was discussed in detail by Gustaf A. Gaffert and Frank V. Smith in an article, Reasons Behind the New University of Illinois Power Plant; published in *Power*, May, 1941. At that time, many buildings and additions had been constructed on the campus, and the old 150-psi plant was badly overloaded, so that considerable power had to be purchased.

In the newer buildings, higher standards of illumination were being planned, air conditioning was required. In 1940, electrical requirements of new buildings, and normal growth of electric load in the remainder of the buildings of about 2 per cent per year, indicated a peak load of about 3400 kw in 1940-41. Since the generating units in the old plant consisted of one 1000-kw and two 500-kw non-condensing units, additional capacity was required. Similar studies indicated that the peak steam demand would increase from 145,000 lb per hr to 200,000 lb per hr in a 10-year period.

Consideration was also given to increasing the illumination standards of the existing buildings and it was calculated that, in order to carry the increased load, the electrical distribution system would have to be changed to a 4160-v, 3-phase, 4-wire system, divided into a number of load areas, each fed by a circuit from the power station with emergency reserve feeder looping through the various areas.

With these considerations in mind, it was decided in 1940 not to attempt rehabilitation of the old power plant but to build a new one at the West end of the campus because:

1. Projected future growth of the campus was to the South.

2. Coal delivery and storage facilities near a permanent railroad line were available there.

3. There was ample space for future plant expansion.

4. Continuous electrical and steam service had to be maintained during power plant construction and this could be done by building a new plant and cutting over the various facilities as completed.

Steam and electrical distribution tunnels and conduits would have to be longer to connect the plant with the existing systems, but this was a minor disadvantage, greatly overbalanced by the advantages enumerated above.

Accordingly, the new plant was built and put into service early in 1940. Physical details were as given by Gaffert and Smith in the article cited above. This plant served the University from 1940 to the present date.

At the end of the war, when the

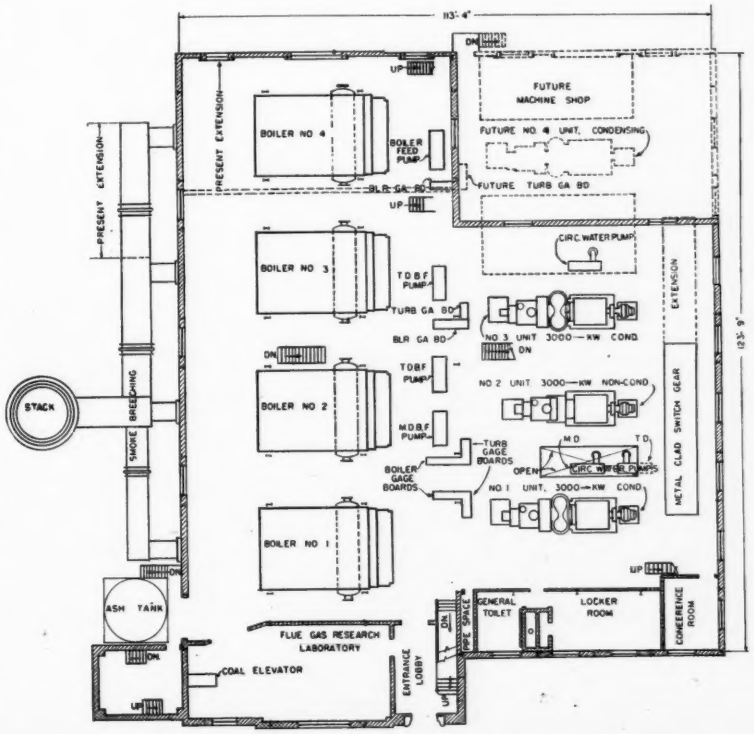


Fig. 2. Plan of Abbott Power Station as it will appear when 1947 extension is completed. Building now being enlarged for No. 4 boiler. New No. 3 turbine generator to be installed in space already provided in existing building. When No. 4 turbine generator is needed, the building will be enlarged again as shown in dotted lines

University enrollment began to expand with returning veterans, and materials again became available, additional new buildings and other facilities were designed and are now under construction. Three new buildings are being erected now to house the departments of mechanical engineering, electrical engineering, and chemistry and chemical engineering, all at the North end of the campus. At other locations on the Campus as shown in Fig. 1 a new residence hall for women is under construction; other buildings are being enlarged. Near the power plant at the West side of the Campus, a new physics research laboratory building has just been completed.

The latter will house the new 100,000,000-v betatron now being built by the University under the direction of Dr. Donald Kerst, professor of physics, for research in pure nuclear physics. During the war, a 22,000,000-v betatron was in operation at the University. Because of lack of other space, also because of its requirements for maintenance of voltage and frequency, this betatron was installed in the basement of the Abbott Power Station. The new building for nuclear physics research has been built near the power plant, the old betatron machine has been moved into it and the building is now being fully equipped for research work.

This betatron machine requires a fairly large power supply but more important than that, it requires maintenance of power supply frequency within very close limits. To accomplish this, special governors are being installed on the power plant turbines, to be described in more detail below. To keep the circuits as short as possible, and minimize line disturbances, the research building was placed as close to the power plant as possible.

How Steam Turbines Supply Exhaust and Extraction Steam

Figure 2 shows the extension of the section of the power plant to house the new boiler and the way in which the No. 3 turbine generator will be installed in the space already provided for it in the existing plant. The future No. 4 turbine generator will be installed as shown by the dotted lines, Fig. 2.

Present plans, based on the expansion of the University expected up to 1955, are for a peak electric load of at least 10,000-kw and approximately 255,000 lb per hr of steam. To supply these loads, the plant heat balance will be as shown in Fig. 4. Generating units are rated at 3000 kw at 0.8 pf, or 3750 kva. Since the power factor of the University electrical system is normally 0.9, the generators will provide the actual amounts of power noted for the conditions of Fig. 4.

As previously noted, No. 2 turbine is a non-condensing unit, equipped with one uncontrolled or non-automatic extraction point. Existing turbine No. 1 and new turbine No. 3 are condensing extraction units, each equipped with one non-automatic extraction point and one automatic extraction point.

The uncontrolled extraction points of all three turbines are connected to supply steam to the high-pressure heaters for feedwater heating, as shown in Fig. 4. The automatic extraction points of Nos. 1 and 3 turbines and the exhaust of No. 2 are connected as shown to supply steam to the steam distribution system. The uncontrolled extraction openings on all three turbines are ahead of the controlled openings and are, therefore, at a higher pressure. But this pressure will vary with the flow of steam through the turbine, and with the pressure at the automatic extraction point.*

Although this non-automatic extraction steam is not controlled at the turbine, a pressure regulating valve is installed in the extraction steam line just ahead of the high pressure heaters, Fig. 4, to maintain a pressure of 60 psi in the heaters, and the uncontrolled extraction point pressure will be above this at all but the lowest loads. For example, the new No. 3 turbine is designed to provide at the uncontrolled extraction point a pressure of 80 psia at half load, with 20 psig pressure at the automatic extraction opening. The non-condensing unit exhausts direct to the 10-70-psi steam distribution system as shown. As a result, by proper scheduling of generation between non-condensing and condensing units, it will be possible to attain optimum station heat rate while

*See article, How to Estimate Turbine Performance with Uncontrolled Extraction, by E. V. Pollard, POWER PLANT ENGINEERING, April, 1947.

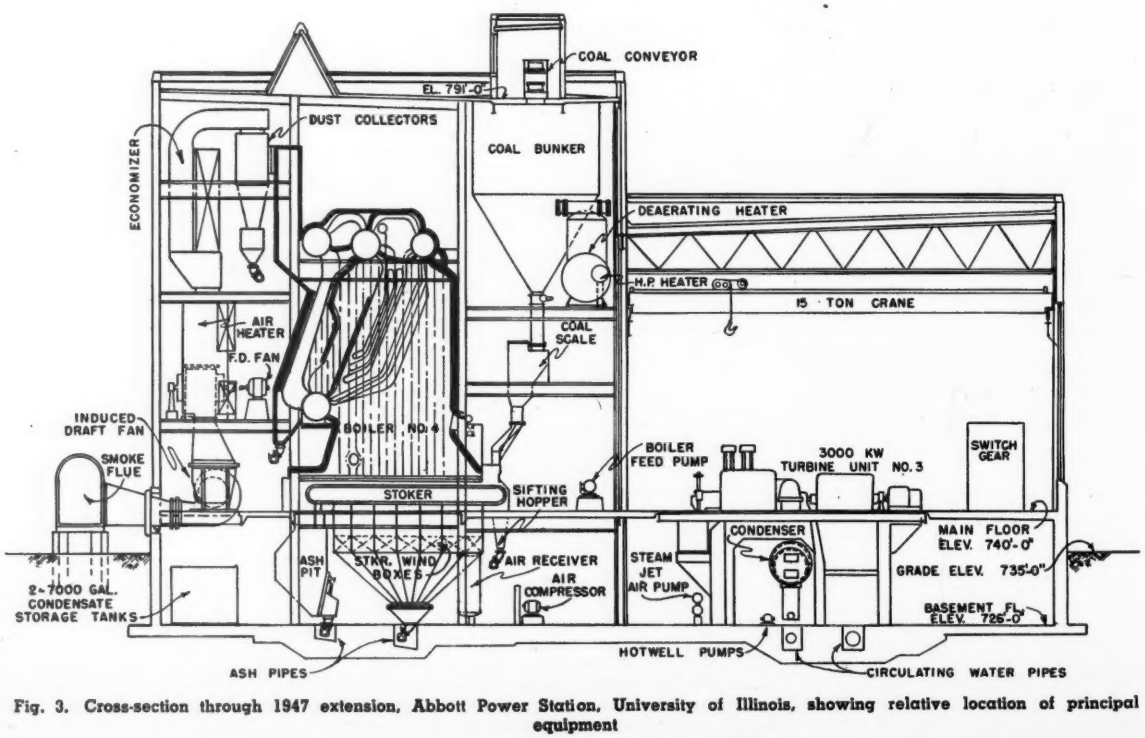


Fig. 3. Cross-section through 1947 extension, Abbott Power Station, University of Illinois, showing relative location of principal equipment

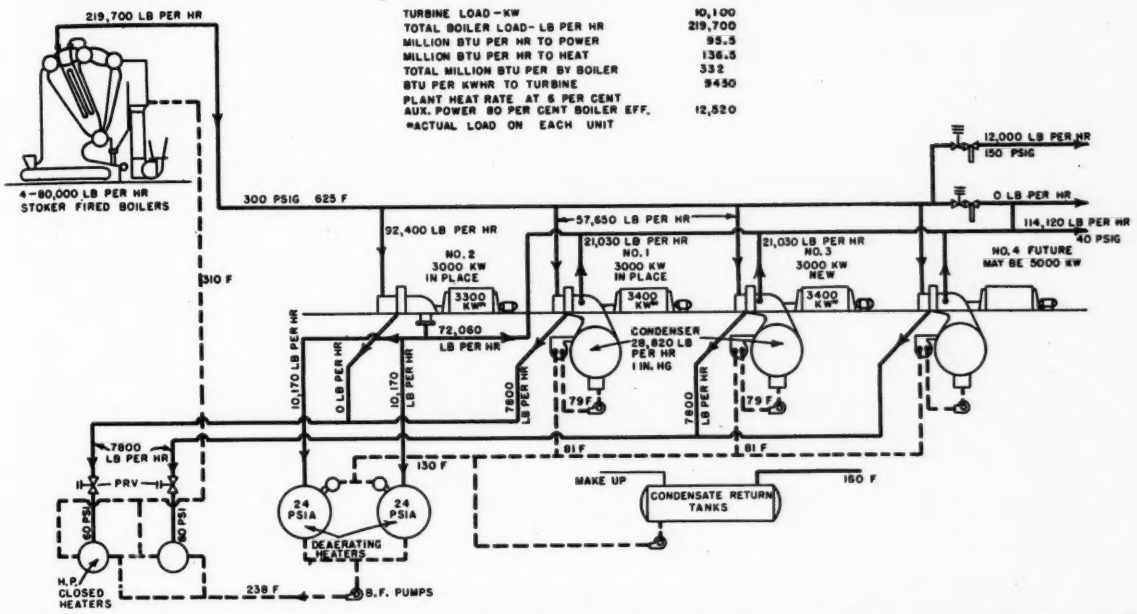

TURBINE LOAD - KW 10,100
TOTAL BOILER LOAD - LB PER HR 219,700
MILLION BTU PER HR TO POWER 95.5
MILLION BTU PER HR TO HEAT 136.5
TOTAL MILLION BTU PER BY BOILER 332
BTU PER KWHR TO TURBINE 9450
PLANT HEAT RATE AT 6 PER CENT AUX. POWER 80 PER CENT BOILER EFF. 12,820
*ACTUAL LOAD ON EACH UNIT
219,700 LB PER HR
4 - 80,000 LB PER HR STOKER FIRED BOILERS
300 PSIG 625 F
310 F
92,400 LB PER HR
57,650 LB PER HR
12,000 LB PER HR 150 PSIG
0 LB PER HR
114,120 LB PER HR 40 PSIG
NO. 2 3000 KW IN PLACE
21,030 LB PER HR NO. 1 3000 KW IN PLACE
21,030 LB PER HR NO. 3 3000 KW NEW
NO. 4 FUTURE MAY BE 5000 KW
3300 KW
3400 KW
3400 KW
72,060 LB PER HR
CONDENSER 29,820 LB PER HR 1 IN. HG
10,170 LB PER HR
0 LB PER HR
10,170 LB PER HR
7800 LB PER HR
7800 LB PER HR
79 F
79 F
7800 LB PER HR
PRV
60 PSI
60 PSI
130 F
81 F
81 F
MAKE UP
160 F
CONDENSATE RETURN TANKS
24 PSIA
24 PSIA
DEAERATING HEATERS
H.P. CLOSED HEATERS
238 F
B.F. PUMPS

Fig. 4. Performance diagram for peak electrical load anticipated by 1955, Abbott Power Station, University of Illinois, Urbana campus

meeting the requirements for feedwater heating, building heating and electricity.

An important feature of the future turbine operations, in addition to meeting the above requirements, is the provision being made on the new turbine No. 3 for extremely close control of frequency in the electrical system for operation of the new betatron. All the rest of the system, such as that supplying various laboratories will benefit by this close control, although few of them require as close regulation as the betatron.

To accomplish this, the new No. 3 turbine will be equipped with a speed corrector in addition to the normal speed governor. The operating governor is to be capable of instantaneous speed regulation within 1 per cent of rated capacity. It must hold the frequency within 0.05 cycles for a load change of 10 per cent between no load and full load. The variation after correction shall not exceed 0.01 cycles per sec up to 1000 kw on a 3000-kw machine. In normal operation, the frequency drift must not exceed 0.01 cycle per sec in 1 hour, when the load change is at the rate of 300 kw per hr. The present No. 1 unit has already had its governor changed to provide this regulation.

Condenser circulating water for the No. 1 and No. 3 turbine condensers must be cooled, since the supply is from the University well-water system. No river or lake is located at the plant. A 2-cell forced-draft cooling tower is already installed for the present plant. Another cooling tower, this one of the induced-draft type, will be installed alongside the present tower to take care of the increased circulating water flow.

Features of the new boiler installation are shown in the cross-section, Fig. 3, and in the list of equipment. Present facilities for handling coal from cars to bunkers are adequate for the total of four units, hence the only additions necessary for the No. 4 boiler are its individual bunker, an extension of the present scraper conveyor over this new bunker, and two more coal scales.

Details of New Boiler and Auxiliaries

Figure 3 shows the shape of the furnace for No. 4 boiler, with a sloping front arch, a moderate rear arch and provision for as much as 10 per cent of total preheated combustion air to be introduced through the front arch as over-fire air. This overfire air is drawn from the preheated air duct by a separate overfire air fan, and is discharged to an air duct feeding the overfire air nozzles. Stoker windbox is divided and dampered for close control of combustion air supply under the stoker, as desired by the operator.

The boiler is equipped with both economizer and air preheater, like its three predecessors; and, like them, has the dust collector installed following the boiler outlet and ahead of economizer, air heater and induced draft fan, to minimize fly ash and erosion in those three units.

The forced-draft fan is motor-driven at constant speed. The induced-draft fan speed may be varied by adjustment of the hydraulic coupling between fan and constant speed motor.

The existing air-operated automatic combustion control will be extended for the new boiler and another control panel added, as shown on Fig. 2, to carry the combustion control master controller, manual to automatic transfers and adjusting devices and boiler recording and indicating instruments.

On this unit, as on the other three boilers, the combustion control will adjust stoker speed-changing devices to maintain steam pressure, will control forced draft by adjustment of forced-draft fan inlet dampers, and will control induced draft by adjustment of the induced-draft fan hydraulic coupling to vary the fan speed.

A new deaerating feedwater heater and a new high-pressure extraction heater are being installed as shown in Figs. 2 and 3, in addition to those in the existing plant. Another motor-driven boiler feed pump is also being installed. The station will then have two motor-driven and two turbine-driven boiler feed pumps, two high-pressure extraction heaters and two deaerating heaters, connected as shown in Fig. 4. No changes or additions are required in the present

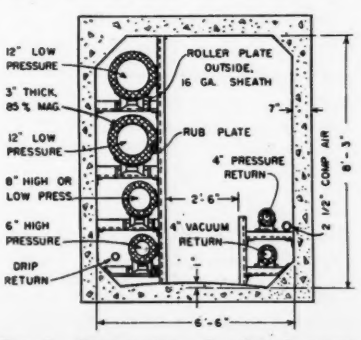


Fig. 5. Cross-section of original steam distribution tunnel, University of Illinois, Urbana campus, as constructed in 1940

LIST OF PRINCIPAL EQUIPMENT—1947 EXTENSION, ABBOTT POWER STATION

University of Illinois, Urbana-Champaign, Illinois

Consulting Engineers—Sargent & Lundy

STEAM GENERATING EQUIPMENT

Boiler (1).....The Babcock & Wilcox Co. Stirling, 4-drum, vertical bent-tube type. Continuous capacity 80,000 lb per hr; 100,000 lb per hr for 2 hr, 315 psi, 700 F at superheater outlet. Boiler heating surface incl. water-cooled furnace walls 9690 sq ft. Steam drum 36 in. dia., 17 ft long; other drum 42 in. dia. Design pressure 400 psi. Furnace heat liberation, 29,600 Btu per cu ft per hr. Furnace volume 3630 cu ft. Average draft loss through boiler 5.3 in. H_2O. Guaranteed boiler efficiency at full load 81.8%.

Economizer (1)..The Babcock & Wilcox Co. Standard continuous-tube type; 15,070 sq ft heating surface.

Air Preheater (1)
The Babcock & Wilcox Co. Tubular type; 4585 sq ft heating surface; 2½ in. tubes, 15 ft long.

Dust Collector (1)...Buell Engineering Co. Cyclone type; 4 cyclones, capacity 42,500 cfm of gas at 625 F at rated boiler output; draft loss 1.13 in. H_2O.

Boiler Temperatures at 80,000 lb per hr Output:

Gases entering economizer	635 F
Gases leaving economizer	497 F
Gases leaving air heater	375 F
Air entering air heater	100 F
Air leaving air heater	250 F
Water entering economizer	300 F
Water leaving economizer	352 F

Stokers.....The Babcock & Wilcox Co. Traveling grate; intermediate heavy duty type; 283.5 sq ft grate surface; drive 7½-hp, 440-v motor.

Overfire Air Fan (1).....B. F. Sturtevant Div., Westinghouse Electric Corp. Capacity to supply 10% of total preheated combustion air over the fire; designed for discharge pressure 15 in. H_2O. Drive, 15-hp motor.

Forced Draft Fan (1).....B. F. Sturtevant Div., Westinghouse Electric Corp. Capacity 30,000 cfm of air at 100 F against static pressure 8.1 in. H_2O. Fan br hp, 68.5. Drive, 75 hp, 1800-rpm constant speed motor, direct-connected; damper control on fan.

Induced Draft Fan (1)...B. F. Sturtevant Div., Westinghouse Electric Corp. Capacity 57,600 cfm of flue gas leaving air heater at 318 F at 40,000 lb per hr steam output and 375 F at 80,000 lb per hr steam output. Static pressure 11.4 in. H_2O. Fan br hp, 189. Drive 200 hp 1200-rpm constant speed motor through hydraulic coupling for fan speed control.

Hydraulic Coupling, I.D. Fan (1)
American Blower Corp.

Soot Blowers
Diamond Power Specialty Corp.

Coal Conveyor (1).....Jeffrey Mfg. Co. Flight scraper type, extension of present conveyor to serve new Blr. No. 4 bunker.

Coal Bunker (1).....Duffin Iron Works

Coal Scales (2).....Richardson Scale Co.

Ash Removal System
United Conveyor Corp. Pneumatic type; extension of present system to remove furnace ash and siftings; fly-ash from dust collector and boiler hoppers.

Feedwater Level Regulator
Northern Equipment Co. Copes Flowmatic, 2 element, responding to steam flow and water level.

Boiler Erection
American Boiler & Tank Co.

Building Construction
Kuhne-Simmons Co.

Automatic Combustion Control (1)
Republic Flow Meters Co. Extension of present system; air-operated; controls stoker speed, forced draft fan inlet and varies induced draft fan speed through hydraulic coupling.

Boiler Control Panel (1)
Republic Flow Meters Co. Republic automatic combustion control and steam flow meters; Bailey boiler meter and draft gages; Leeds & Northrup temperature recorder; Bailey stoker speed indicator actuated from Republic stoker speed regulator; Builders-Providence condensate and water flow meters; Weston ammeters for fan motors.

Valves
Non-return.....Edward Valves, Inc.
Blow-off.....Okadee Valve Co.
Safety.....Consolidated
Main steam and water.....Crane Co.
Atmospheric and relief..Davis Valve Co.
Globe, gate and angle
Edward Valves, Inc.

Flues and Ductwork
Connery Construction Co.

POWER GENERATING EQUIPMENT

Turbine Generator (1)
General Electric Co. Extraction condensing type 3000-kw, 3600 rpm, Turbine 16 stages; throttle steam conditions 300 psi, 700 F. Two extraction points: at 4th turbine stage, uncontrolled, supplying 7800 lb per hr to closed feedwater heaters at full load, and at 12th turbine stage, automatically controlled, supplying 21,300 lb per hr of steam at 40 psi at full load to steam distribution system and deaerating heaters. Generator capacity 3750 kva, 3000 kw at 0.8 pf, 4160 v, 3 phase, 60 cycle. Shaft-driven exciter, 25 kw. Turbine governor equipped with special speed corrector to maintain very close frequency regulation for betatron, as described in text.

Condenser (1)
Worthington Pump & Machinery Corp. Two-pass, 3500 sq ft surface type to condense 38,000 lb steam per hr with 5000 gpm circ. water Des. vacuum at turbine outlet 3.03 in. Hg with 90 F water; 1.35 in. Hg with 60 F water. Friction loss through cond. tubes 8.7 ft. Condenser tube surface 3500 sq ft 1092 arsenical copper tubes ⅞ in. O.D. 14 ft long, 18 BWG. Equipped with integral hot well, 2-stage jet air ejector, with intercooler and after condenser. Ejector capacity at 3 in. Hg abs in condenser, 94 cfm of free air.

Generator Air Cooler.....G. E. Co. Tubular, 2490 sq ft.

Turbine Oil Cooler.....G. E. Co. Twin type, capacity 25 gpm with 50 gpm of 90 F to 96 F water.

Circulating Water Pump (1)
Worthington Pump & Machinery Corp. Horizontal, split-case, double-suction, single-stage; 5300 gpm at 880 rpm against 41 ft net ext. hd. Total net hd 49.7 ft including condenser loss. Speed 880 rpm. Drive, 100 hp, 440 v, 880 rpm motor.

Turbine Controls and Instruments
G. E. turbine speed indicator; Builders-Providence Flo-watch venturi meter for hot well condensate; Republic flow meters for steam flow to heaters; Ashcroft steam pressure gages.
Absolute pressure gage for turbine exhaust.....American
Mercury columns and vacuum gages
Precision T & I Co.
Motor switches, automatic relays and alarms.....Westinghouse, Cutler-Hammer and G. E.
Frequency recorder (now in place)
Leeds & Northrup Co.

Main Switchboard Extension for Unit No. 3
Allis-Chalmers Mfg. Co.

Cooling Tower (1)...Foster Wheeler Corp. For condenser circulating water, 2-cell induced draft type, to handle 5500 gpm water at 104 F to tower, leaving at 90 F; with wet bulb temp 78 F. Spray loss 0.2%, estimated evaporation loss 2.28%. 2 motor-driven aluminum-bladed fans, 14 ft dia., 4 blades per fan, adjustable pitch capacity each fan 209,000 cfm. Drive, each fan, G.E. 30-hp, 440-v, 1800-rpm motor driving fan at 274 rpm through gears. Air pressure loss through tower, 0.50 in. H_2O. Assumed outside wind velocity, 0. Total water head from top of basin, 30 ft. Supply pipe 24 in. Tower 49 ft 6 in. long, 25 ft 6 in. wide, 21 ft 3 in. high.

PUMPING AND FEEDWATER HEATING EQUIPMENT

Boiler Feed Pump (1)
Pennsylvania Pump & Compressor Corp. Capacity 100,000 lb per hr; suction head 20 psig, discharge head 450 psig, handling 238 F water. Pump br hp 85.5. Pump speed 3560 rpm. Drive, 100-hp, 3600-rpm, 440-v motor. This pump is added to three others now installed—2 turbine driven and 1 motor driven.

Hotwell Pumps (2)
Worthington Pump & Machinery Corp. Capacity 100 gpm each against 180 ft total head; two-stage. Drive, 15-hp, 1750-rpm, 440-v motor.

High-Pressure Heaters (1)..Alco Products Div., American Locomotive Co. Tubular, 4-pass, 509 sq ft, normal capacity 150,000 lb water per hr, maximum capacity 200,000 lb per hr, heating water from 238 F to 300 F with 10,300 lb per hr of 78 psia steam. Terminal difference 10 deg; water velocity 5.45 ft per sec. Welded steel shell 12 ft 1 in. long, 21⅛ in. I.D. Arsenical copper tubes, 300 tubes, ⅝ in. O.D. 18 BWG. 103⅛ in. long. Crosby relief valves on water box and shell; Fisher high water alarm and condensate drain valve and float control.

Pressure Regulating Valve Ahead of hp Heater.....Fisher Governor Co.

Deaerating Heater (1)
Worthington Pump & Machinery Corp. Horizontal, capacity 200,000 lb per hr of outlet water containing not more than 0.03 cc per liter of O_2 (Winkler or Schwartz-Gurney). Shell 7 ft 6 in. I.D., 5 ft 2 in. long, 186 trays 27 by 4 in. Total surface 20,100 sq in. storage 3500 gal H_2O. Vent condenser 2-pass, 82 sq ft tube surface tubes ¾ in. O.D., 41 in. long. Fisher float control.

Air Compressor (1)
Pennsylvania Pump & Compressor Co. Reciprocating, 2 cylinder, compressing 391 cfm of free air to 100 psi at 466 rpm. Inter and after-cooler. Drive, 100-hp, 440-v, 1750-rpm motor through V-belt.

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zeolite feedwater treatment system, which has adequate capacity to provide necessary make-up water for the new boiler and turbine.

Except for the two turbine-driven boiler feed pumps, one condensate elevating pump, and one hot well pump, all other boiler and turbine auxiliaries are driven by 440-v motors. These are supplied with power from the main bus by the two existing 750-kva auxiliary power transformers, a third new one having been installed as a spare. Generation is at 4160 v. Electrical controls are operated by direct current from motor-generator sets, with a storage battery floating on the line. The present interconnection of the electrical distribution system with the transmission system of Illinois Power Co., through the substation erected for that purpose in 1940 adjacent to the power plant, will be continued to provide for emergencies.

As noted above, extension of present steam distribution tunnels and electrical conduits to serve new buildings now under construction constitutes a vital part of the work now going on. Existing main steam distribution tunnels, leading out from the power plant and shown in cross-section in Fig. 5, are well designed to carry the piping and allow adequate space for maintenance work. Piping is supported on structural steel framework. Tunnels are 6½ ft wide and 8 ft 3 in. high, built of re-inforced concrete with piping arranged as shown.

The new tunnels, which extend the

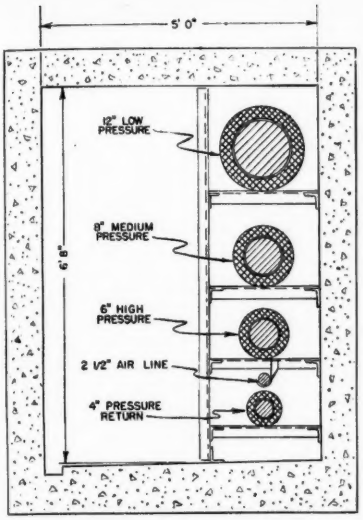


Fig. 6. Cross-section of new 1947 distribution tunnels extending services to new buildings on Urbana campus

steam distribution system to furnish new services, are of slightly different construction from the main tunnels and are shown in cross-section in Fig. 6. Since they are distributing steam fed into them from the main tunnels at various points of the loop, they do not contain as much piping. It will be noted on Fig. 6 that only a pressure return line is shown. This is because the system is being gradually changed over from vacuum return to pressure return, hence all the new extensions will be of the latter type.

In the original tunnel piping system, no loops were used at the corners. The pipes were allowed to rest on roller type supports, as shown, to provide for the necessary movement. During the past two years, another type of support has been developed and tested, and is being used in all the new tunnel extensions. As illustrated in Fig. 6, it consists of a simple metal band, fitted tightly over the pipe insulation and sliding on the flat side of an inverted channel iron which forms the supporting steelwork, with no rollers between. At present, this seems to be working out satisfactorily. Various tests, together with inspection, show that movement of the pipe is apparently not crushing or damaging the pipe insulation.

Design of the original Abbott Power Station and steam and electrical distribution system and of the present extensions was carried out by Sargent & Lundy, consulting engineers, Chicago, co-operating with the Physical Plant Department of the University of Illinois, which operates and maintains all the physical services of the University. C. S. Havens is director of the Physical Plant Department. John Doak is superintendent of the Operation and Maintenance Division, of which the author is superintendent of utilities, having direct supervision of the power plant and its services.

THE STRENGTH OF AMERICA

(Continued from page 51)

year is too complex for rigid planning and the enforcement of detailed plans by law. We must function in a loose, informal way under sanctions that are largely ethical and moral, based upon commonly accepted standards of fair play and respect for human integrity. This is the way we do function, by and large, and this is why we flourish.

Some would have us believe that because we excel in making millions of the same kind of useful gadgets, that therefore we are free men. No, that has the cart before the horse. It is because freedom for men is a primary ethical concern of ours that we do so well in making gadgets and raising food and doing successfully many other things—among them the winning of wars.

Diversity and flexibility rather than a stereotyped hard-and-fast system, is an essential part of such a noble concept of society as is ours. We get our economic services in the way that at the time seems to work best, that will in a particular situation best advance our underlying purposes. We do not start with all the answers, the economic or political answers. We make the answers up as we go along. Thus, American industry is owned and operated, by and large, by competitive private enterprise; yet a year ago the Senate of the United States voted unanimously to establish public ownership and management in one of our largest industries, and make it a government monopoly—I refer of course to the atomic materials industry. That appeared to be the thing to do at the time, for reasons related to the facts of atomic energy, not for ideological reasons taken out of some book of economic dogma. The most rock-ribbed midwestern town I know has for many years owned and operated its own electric power and light plant. Is this then a "socialist" town? Hardly! Its water service has been privately owned for the same period. There is a privately-owned university; a public junior college. No one considers that these things are inconsistent; and of course they are not, except to the dogmatist who thinks we have a fixed "system." In the same town there is a farmers' feed cooperative that is not quite private or quite public, operating side by side with a big privately-owned feed company. There are private banks, there are non-profit insurance companies, there are state-owned liquor stores. We would never consider adopting government ownership or control of newspapers partly because of their educational character; but our school system, the cornerstone of American education, is almost entirely publicly owned and managed. This is all part of the familiar picture of American diversity, of American flexibility.

The fact is that we have hardly an ounce of economic dogmatism in us. This characteristic diversity of ours, this capacity to adapt ourselves to any need, stands us—and the world—in good stead today. For in Western Europe there are many different kinds of economic undertakings and methods of control; and as befits world leaders we are peculiarly equipped by reason of our own economic diversity to deal effectively with each of these, without sacrifice of our own unifying sense of purpose and direction.

We ourselves should be very clear about American fundamentals, as we move into the most fateful role we have ever played in world affairs. For our leadership in large part depends upon our continued capacity to demonstrate how superior, in human terms, is our way of living. If I am right in what I have been saying, then it is important—desperately important—that we be clear in our own minds about the true sources of our strength; that we nourish and safeguard the ethical principles that make us strong.

Now no candid person—no honest person—would deny that there are today some disturbing tendencies in our country away from this concern for the individual, away from our standards of fairness between men. We are witnessing in some quarters as ugly a scene of hoggishness and moneymania as we have seen since the days of the twenties. Many of those who spent the years of their youth fighting for this country returned to find themselves the victims of legal crookedness and outrageous speculation. These and other evidences of disregard for our ethical precepts do exist in some quarters; and to the extent that they exist they poison the wells of our material as well as our spiritual strength.

These are days when we should recall the stirring words of old Walt Whitman:

"It is not the earth, it is not America
who is so great,
It is I who am great or to be great,
it is You up there, or any one,
It is to walk rapidly through civilizations, governments, theories,
Through poems, pageants, shows, to
form individuals.

Underneath all, individuals, I swear
nothing is good to me now that
ignores individuals. . ."

WHAT THE POWER ENGINEER SHOULD KNOW ABOUT

Flame Failure Protection

Need for flame failure control devices . . . Classes of flame failure control systems . . . Devices making use of flame conductivity . . . Photoelectric flame failure control devices . . . How the electrode type of system operates . . . Details of the photoelectric type of system . . . Constructural features . . . Operation, care and maintenance

FLAME FAILURE CONTROL DEVICES, for use in protecting furnaces against explosions are of two general classes; 1, those utilizing the electrical conductivity of the flame and 2, those sensitive to the radiation from the flame.

Basically, both classes, are simple in operation. In the case of the first class—those utilizing the electrical conductivity of the flame, an insulated electrode is arranged near the burner so that when the burner is in operation the electrode makes contact with the flame. The principle is shown in Fig. 1. The relay circuit, it will be noted is completed through the flame. As long as the flame exists, current flows from the burner through the flame to the electrode and energizes the relay. This in turn keeps the fuel oil valve open. The instant the flame fails, the relay opens and the weight loaded valve closes, shutting off the fuel oil supply. This type is used primarily with gas firing.

The Photoelectric System

The arrangement in the second system is similar except that in this case there is no physical or electrical contact between the relay circuit and the flame. The connection is the radiation from the flame itself. This is picked up by either a light or heat sensitive device which closes the relay circuit. In most systems of this type a photoelectric cell is used but in some cases (used only for small, domestic type furnaces) a sensitive thermal relay, "views" the flame.

Where flame failure devices are installed on large boilers, the relay usually controls an alarm or warning signal, notifying the operator that the burner is not operating. He then makes the necessary adjustment manually.

Of course, neither of these systems are quite as simple as shown in the two diagrams. The resistance of an ordinary flame may be anywhere between 1.5 and 150 megohms. Thus, even with the lower value and a battery of 1000 v potential, the current would be only 1000 ÷ 1,500,000 or 1/1500 amp. At the upper value, the current would be only 1/150,000 amp. These currents are not sufficient to operate ordinary industrial relays, so an electron tube amplifier is necessary. The amplifier is a standard high vacuum tube amplifier, similar to the one used in your home radio. By making the path through the flame part of the grid circuit of an amplifier tube, minute changes in current through the flame can be made to control a relatively powerful plate current which in turn can actuate the relay. In the case of one commercial form of this protective system, as long as the resistance of the flame is anything between 1.5 and 150 megohms, the control system serves to keep the fuel supply on. If the resistance should exceed 150 megohms (a megohm, of course, is a million ohms) there would be no flame and the device would automatically shut off the gas. The actual manner in which this is accomplished varies in different systems but basically, the principle of using the flame as a conductor is the same.

Makes Available

The Brown Instrument Company's "Protectoglo" system, the Wheelco Instrument Company's Flame-Otrol system and the Combustion Control Corporation's "Fireye" Electronic Flame Rod system are systems using the flame conduction principle. This type of system is positive, since it depends upon the actual presence of the flame for its operation. It is suitable for a wide variety of applications not only in furnaces under power plant boilers but also for industrial heating furnaces, ovens, etc.

The photoelectric type of system, is particularly suitable for use with large power boiler furnaces—where capacities and temperatures run very high and where operation is continuous over long periods of time. The furnaces in such cases are very large, the fuel burning capacity high, consequently, the explosion hazard high. Such furnaces operate at temperatures, such that if ignition is lost by stoppage of the fuel supply, a resumption of fuel flow not accompanied by instant ignition would generate a dangerous explosive mixture in the furnace in a matter of seconds. The

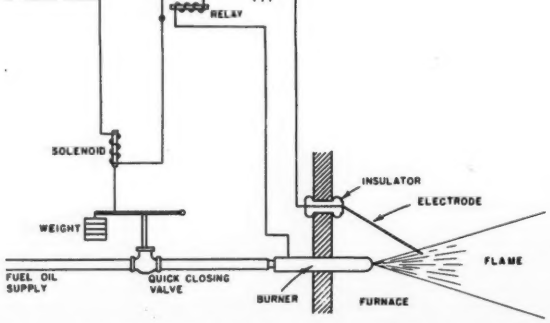


Fig. 1. Schematic diagram of the electrode type of flame failure system

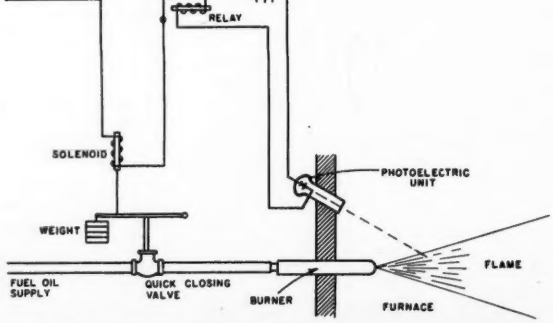


Fig. 2. Schematic diagram of the photoelectric system

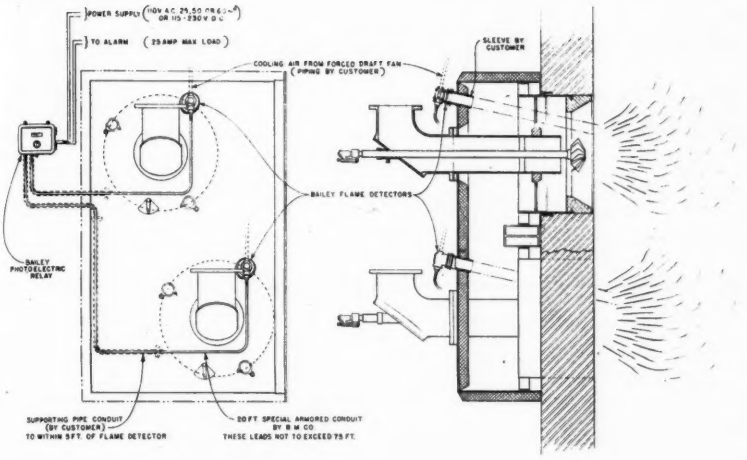

POWER SUPPLY
TO ALARM
(25 AMP MAX LOAD)
COOLING AIR FROM FORCED DRAFT FAN
(PIPING BY CUSTOMER)
SLEEVE BY CUSTOMER
BAILEY FLAME DETECTORS
BAILEY PHOTOELECTRIC RELAY
SUPPORTING PIPE CONDUIT (BY CUSTOMER) TO WITHIN 5 FT. OF FLAME DETECTOR
20 FT. SPECIAL ARMORED CONDUIT BY B M CO
THESE LEADS NOT TO EXCEED 75 FT.

Fig. 4. Section through a photoelectric flame failure detector showing heat absorbing glass discs, copper cooling fins and path of cooling air

residual heat of the furnace, easily ignites such mixtures, resulting in a major explosion.

For this reason, it is extremely important that some means be provided whereby, the instant ignition is lost, the supply of fuel to the furnace is cut off automatically or manually. A photoelectric tube, properly mounted in an air-cooled housing provides this need. This device is usually mounted on the burner front or boiler wall, so that the phototube "sees" the flame at the point where ignition begins to take place. As long as the burner continues to maintain ignition, light from the flame reacts on the phototube, causing it to have low electrical resistance and thereby maintain a flow of current through the amplifying tube in a relay circuit.

In case of flame failure, light to the phototube is immediately reduced, since its line of sight is trained at the point of ignition, where flame failures always start. Without direct light from the flame, phototube resistance increases sharply and the flow of current in the amplifier is reduced with the result that the relay operates to close or open contacts for sounding an alarm, or actually cutting off the fuel supply.

Method of Installation

A diagram of a photoelectric flame failure detector is shown in Fig. 3. This is the Bailey Flame Detector made by Bailey Meter Co. In this particular case, the detector housing is welded to a 4-in. pipe sleeve of suitable length, which in turn is welded to the burner windbox, so that the phototube "looks" at the fire through the secondary air opening in the burner. This location insures positive, reliable, and proper functioning of the flame detector without its being influenced by red hot refractory walls, or incandescent slag on the furnace wall tubes. By aiming the detector in this manner, a decided change in the light intensity received by it, takes place the instant the flame failure starts, since black coal or oil comes into its line of vision, instead of actual flame. In general, when two or more burners are used on a boiler, flame failure detectors should be installed on each burner. When firing with pulverized coal using the unit system, a separate photoelectric relay and warning signal may be desirable for each pulverizer.

On certain multi-burner installations it is possible to locate a single detector in the furnace wall to look across the flames from all burners.

Several manufacturers make photoelectric flame failure detectors. Among those suitable for large boiler operation are the Bailey Meter Co.; flame detector, the Wheelco Instrument Co., "Flame-Eye," Combustion Control Corporation's "Fireye," and Brown Instrument Company's "Protectoglo."

Basically, these devices are all alike but each has its particular differences in circuit design, actual mechanical construction and method of installation. The principle requirement in the installation of the photocells is that they be mounted in such a manner as to be protected against the high temperature of the furnace. This is usually accomplished by mounting the tube in an air-cooled housing using heat resisting glass filters. In Fig. 4 is shown a diagram of the Bailey flame detector. As shown, two heat-absorbing glass discs protect the phototube from direct radiant heat. Heat which might be conducted from the burner box or furnace wall is dissipated by two copper cooling fins.

A ¾ in. pipe connected to the flame detector housing immediately over the phototube provides for the circulation of cool air from the forced draft fan, over the phototube, around the heat absorbing glass discs, and into the pipe sleeve connecting the flame detector with the burner box. This stream of air serves the added purpose of preventing the accumulation of dirt and dust on either the phototube or the protecting glass.

Operation

In the operation of any of these devices, it is important that the phototube and its housing be kept clean, and in the case of the electrode systems, that the electrodes be kept clean and in contact with the flame. Where the phototube is used, it should be tested from time to time. In the Bailey system this is very simple, since a spare phototube is included in the photoelectric relay together with a small incandescent lamp. By lighting the lamp, the milliammeter in the amplifier circuit will deflect to between 80 and 90 per cent of the full scale reading if the tube is satisfactory.

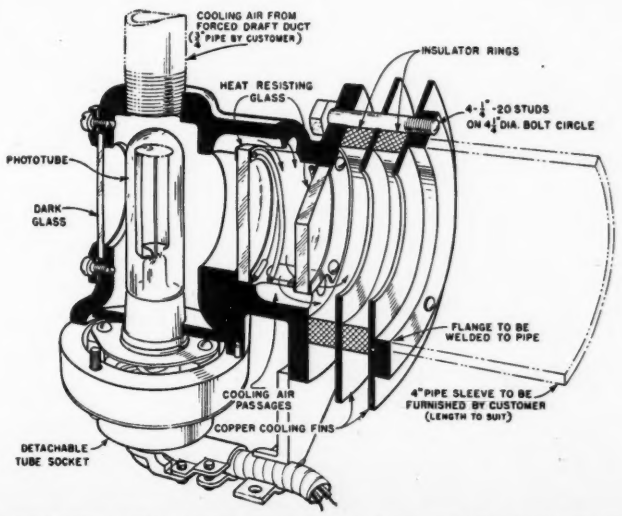

COOLING AIR FROM FORCED DRAFT DUCT (¾" PIPE BY CUSTOMER)
INSULATOR RINGS
HEAT RESISTING GLASS
4-½"-20 STUDS ON 4½" DIA. BOLT CIRCLE
PHOTOTUBE
DARK GLASS
FLANGE TO BE WELDED TO PIPE
COOLING AIR PASSAGES
4" PIPE SLEEVE TO BE FURNISHED BY CUSTOMER (LENGTH TO SUIT)
COPPER COOLING FINS
DETACHABLE TUBE SOCKET

Fig. 3. Application of the photoelectric type of system to a boiler fired with pulverized coal and oil, using preheated air

Combined Operation of Steam and Hydro Stations

By VINCENT A. THIEMANN

Assistant Chief Engineer, Wisconsin Public Service Corp., Green Bay, Wisconsin.

WHEN ADDITIONAL electric generating capacity is planned, the overall costs of a water power in serving the load are compared with those of an alternate fuel station. After the choice between steam and hydro has been made, these two types of plant are operated to supplement each other, securing the advantages of each. The generating system of the Wisconsin Public Service Corp. is a probably typical combination of steam and hydro generating stations in the Midwest. This article will illustrate the factors in the coördination of hydro and steam plant operation by examples from the power system of that company.

This is a completely new and different treatment, written especially for POWER GENERATION (formerly POWER PLANT ENGINEERING) of a subject first presented before the 1947 Midwest Power Conference.

Steam stations are 60 per cent of Public Service installed capacity. The J. P. Pulliam Bayside Steam Station at Green Bay, with 80,000 kw capacity, has its dock to which self-unloading lake steamers bring 10,000 tons of coal each trip. Two older 10,000 kw steam stations are used for standby because the greater efficiency and access to water-borne fuel make Bayside the most economical. Eighteen hydro stations have a total installed capacity about 65,000 kw, which illustrates the comparatively small capacity of the individual water powers in this section.

Physical Factors in Combined System

The investment in company steam stations is $100 a kilowatt, compared to about $170 a kilowatt installed in the hydro plants. The higher investment that is characteristic of water powers is offset by their lower production costs. In 1946, the output of Public Service steam plants was 297,000,000 kwh with a production expense of 5.5 mills of kilowatthour; the hydro unit production cost was one-fifth of that amount for 309,000,000 kw output. The contribution in meeting the monthly peak loads averaged 57,300 kw for the fuel plants and 50,600 for the water power. Because the latest 30,000-kw addition to steam capacity was placed in operation in August 1947, the above statistics are for a steam capacity of 70,000 kw.

Work has started in a 50,000-kw addition to Bayside steam station, for operation in 1949. Wisconsin Public Service Corp. has entered into a contract with two other utilities contemplating the construction of two hydro

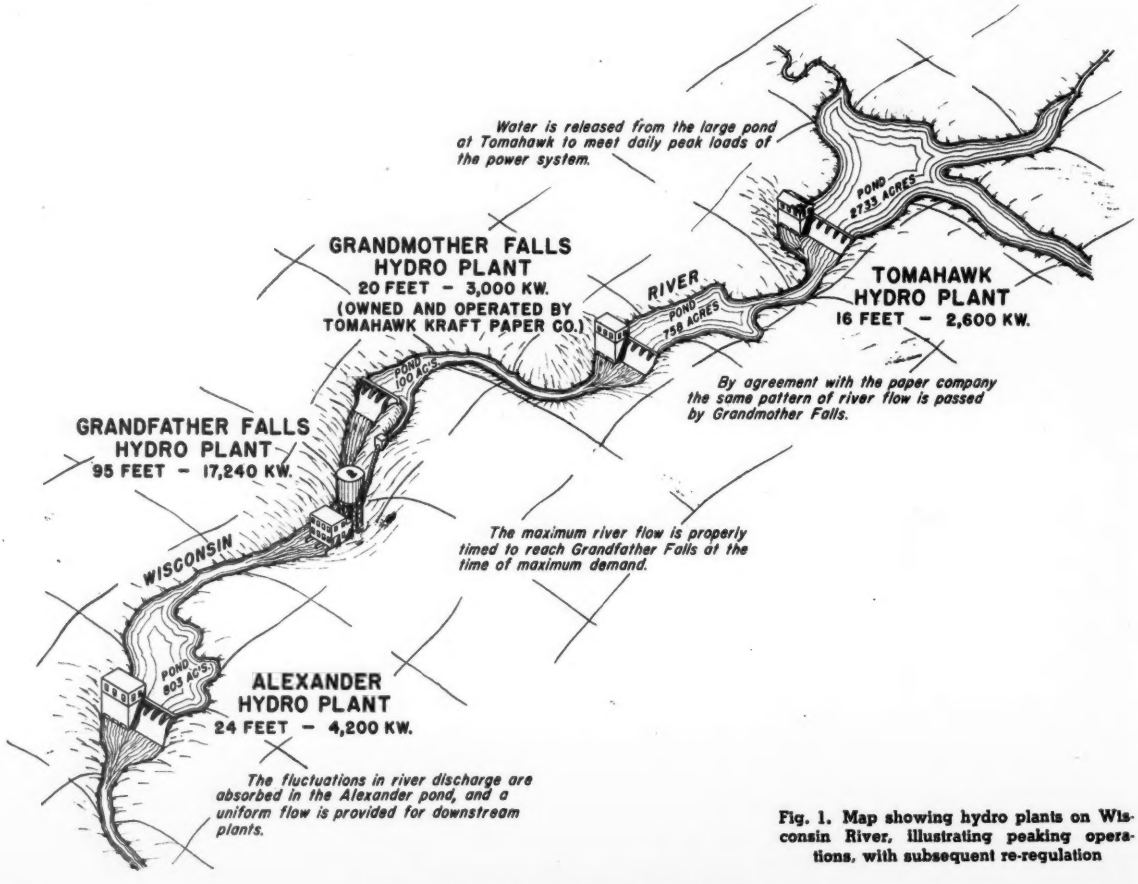

Water is released from the large pond at Tomahawk to meet daily peak loads of the power system.
POND 2733 ACRES
TOMAHAWK HYDRO PLANT
16 FEET – 2,600 KW.
RIVER
POND 750 ACRES
GRANDMOTHER FALLS HYDRO PLANT
20 FEET – 3,000 KW.
(OWNED AND OPERATED BY TOMAHAWK KRAFT PAPER CO.)
POND 100 ACRES
By agreement with the paper company the same pattern of river flow is passed by Grandmother Falls.
GRANDFATHER FALLS HYDRO PLANT
95 FEET – 17,240 KW.
The maximum river flow is properly timed to reach Grandfather Falls at the time of maximum demand.
WISCONSIN
POND 603 ACRES
ALEXANDER HYDRO PLANT
24 FEET – 4,200 KW.
The fluctuations in river discharge are absorbed in the Alexander pond, and a uniform flow is provided for downstream plants.

Fig. 1. Map showing hydro plants on Wisconsin River, illustrating peaking operations, with subsequent re-regulation

Steam and hydro plants employed in one power system must be properly co-ordinated to secure advantages of each . . . Principles of combined operation illustrated in system of Wisconsin Public Service Corp. . . . Description of stations and capacity available . . . Influence of steam plant efficiency; influence of automatic hydro . . . Peaking ability usually required in utility hydro plant . . . Most economical combined operation when hydro carries peaks, fuel stations run on base load . . . Hydro units on the line quicker than steam . . . How to analyze load characteristics, energy output, maximum demand, load factors to get best operation . . . How to use load-duration and peak percentage curves . . . Seasonal runoff factors . . . Availability of steam and hydro . . . Forecasting

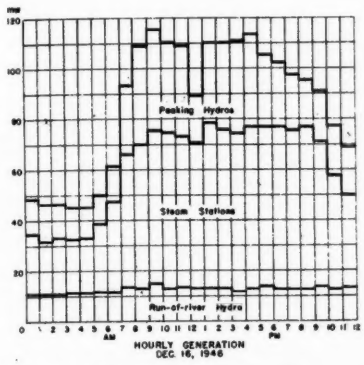


Fig. 2. Graphs of hourly generation on WPS system for the day of 1946 maximum demand

projects on the Wisconsin River with a combined installation of 35,000 kw; the output is to be shared by the three electric companies.

In determining if an undeveloped water power is economically feasible, compared with an alternate steam station, in supplying the market, the annual charges of each should include the applicable transmission costs. This usually favors power sources close to the load centers. While Public Service has over 1300 miles of transmission circuits, the average distance electricity was transmitted last year was only 36 miles, while 18.5 per cent of energy delivered to distribution lines was received directly from generating stations. This illustrates the intimate relationship between the generation and the load we regard as essential.

Due to the long life of hydraulic structures, proposed water power projects must compete with future fuel efficiency; even, perhaps, with nuclear energy. Many Public Service hydro stations were built when generation of a kilowatthour by steam required over 4 lb of coal; compared with less than a pound today. Increasing fuel efficiency and interconnections might have forced the abandonment of older hydro stations, except for the introduction of automatic operation. The use of automatic and remote control equipment is particularly advantageous for small hydros, which might not be justified with full-time operating shifts. Six plants were originally constructed for automatic operation, and five others have been converted to partially automatic. The results were improved operation, lower costs, and less investment. Four hydro stations on the Peshtigo River with 22,000 kw total capacity are controlled from one point, which makes load dispatching simpler and quicker than individual plant control.

Peaking or Run-of-River Hydro

Hydro plants may be classified as either peaking or run-of-river. Because of insufficient pond storage, or possibility of interference with downstream riparians, a run-of-river plant must take the water as it comes, and operates at a more or less uniform output 24 hr a day. A peaking plant can manipulate the river flow, storing water during the night and generating maximum output at times of peak load. Peaking operation of a hydro station refers to the daily use and replenishment of the pondage, as distinguished from the seasonal operation of storage reservoirs.

In the investigation of a proposed water power development, a low cost of the usable hydraulic energy will make the hydro plant attractive only if coupled with a proportionate firm or dependable capacity to meet peak loads. This usually requires peaking ability in a utility hydro plant.

How Peaking Hydro Operates

For a hydro to operate as a peaking plant, a pond of moderate area is necessary upstream, the level of which can be varied to some extent, so that the stream flow can be utilized to fit the load curve. In some cases it is necessary to re-regulate at a lower plant, smoothing out the discharge for some plant farther downstream which does not have sufficient pondage or waterwheel capacity to take fluctuating river flow. Figure 1 illustrates the peaking operation of a group of hydro stations with subsequent re-regulation. Grandfather Falls is the largest Public Service hydro station, but its pond area of 100 acres is too small for peaking. A one-foot drawdown would permit full load operation for only an hour. However, a 4-in. variation in the larger pondage at Tomahawk plant allows full load operation of the upper three plants shown in the diagram for eight hours a day under conditions of minimum river flow.

Combined operation of steam and hydro generating plants is most economical when the water powers carry the peak loads and the fuel stations run at base load. This operation results in a higher energy output and a greater maximum demand for the power system than if both types of generating equipment operate at the system load factor, or if the hydro plants are run-of-river and the steam stations carry the peaks. In addition, the greater flexibility of hydro plants adapts them to carry peak loads. Figure 2 graphs the hourly loads on the generating system for the day of 1946 maximum demand; it shows the steam stations and run-of-river hydros operating at a more sustained loading, with the peaking hydros carrying the shorter duration peaks.

Hydraulic generating units can follow rapid swings in load more readily than can steam, where a major variation in load involves changing the pulverizers, pumps, and fans in service. Hydro units can be put on the line in a matter of seconds, while a steam turbine and boiler may require several hours. This greater flexibility of hydro units adapts them for service as spinning reserve and cold reserve. Even a run-of-river plant has enough pondage to pick up full load for an hour or so in an emergency. In the spring, melting snow usually creates a higher runoff than during the rest of the year, and in that period steam generating units are taken

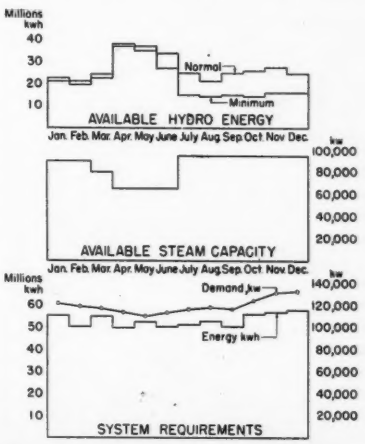


Fig. 3. Diagrams of available hydro energy, available steam capacity, system requirements for an average year and in lowest year

out of service for inspection and overhaul.

To correlate the operation of hydro and steam plants, the firm capacity of both, the hydro output, and the load characteristics must be determined. The top part of Fig. 3 illustrates the monthly distribution of hydro output for an average year and in the lowest year. The middle graph of this figure shows the reduction in steam station available capacity due to scheduled maintenance outages. On the lower portion of Fig. 3, the system power and energy requirements are shown. It will be noted that steam station maintenance is deferred until the period of the year when runoff is greatest and the load is the least. The average hydro output on our system is 325,000,000 kwhr, with 255,000 kwhr available in the lowest year. The hydro contribution toward the monthly maximum demands averages 52,000 kw in a normal year and 47,000 in the minimum year.

The energy output of water power is determined by the river flow. A

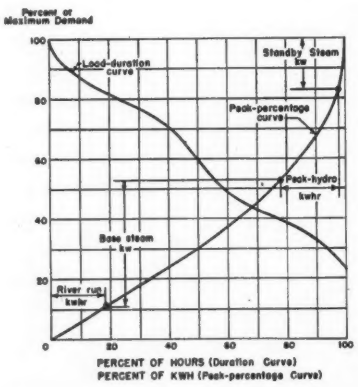


Fig. 4. Load-duration and peak-percentage curves useful in determining capabilities of combined operation. Derivation explained in text

certain quantity of kilowatthours is available; the kilowatts of demand depends upon the number of hours the hydro station operates. When fuel plants carry base load, the firm capacity of peaking hydro stations is increased; this is especially important in times of low river flow. The hydro capability to meet peak load also depends upon the shape of the system load curve, of which load factor (the ratio of average to maximum load) is a measure. The tabulation below illustrates the relationship between the three factors:

	Maximum Demand (kw)	Energy Output (kwhr)	Load Factor {kwhr / kw × hr}
Steam	Fixed (kw × L.F. × hr)		
Hydro	{kwhr / L.F. × hr} Fixed		
Totals	Fixed (by load)		

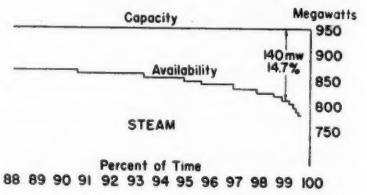
It is apparent that the total maximum demand increases as the hydro load factor decreases; the total output increases with steam station load factor; both the steam and hydro load factors depend upon each other and upon the system load factor, which depends upon the load.

Use of Load-Duration and Peak-Percentage Curves

Load-duration and peak-percentage curves such as shown in Fig. 4 are useful in determining the capabilities of the combined generating stations in meeting the system load. A load-duration curve is made by arranging the hourly loads in descending order of magnitude, disregarding the time they occurred. This load-duration curve shows, for example, that loads as high or higher than 90 per cent of the maximum occurred 6.5 per cent of the time, or 48 hr in the month.

The peak-percentage curve is derived from the load-duration curve and is somewhat more useful. Since the scales of the load-duration curve represent kilowatts and hours, the area under the duration curve represents kilowatthours. The peak-percentage curve shows the ratio of the kilawatthours (area of the duration curve) of all loads up to any specified demand, to the total kilowatthours. The peak-percentage curve shows that loads up to 90 per cent of the peak kilowatt include over 99 per cent of the kilowatthours; conversely, the top 10 per cent of the demand requires less than 1 per cent of the energy. This illustrates the leverage by peaking hydros; a relatively small water power output can make a considerable contribution to demand capacity.

Some Public Service hydros have pondage for daily but not weekly peaking, hence only 5/7 of their output is available for weekday peak loads, excluding Saturday and Sunday. The other 2/7 of their output is included with run-of-river. In Fig. 4 the peaking hydros have a 39 per cent load factor, and the base load steam 85.5 per cent, compared to a 60 per cent system load factor. For other load factors the load-duration and



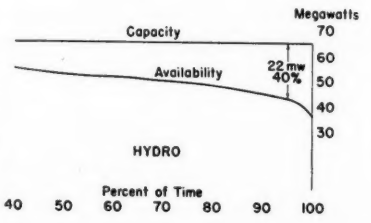


Fig. 5. Percentages of time hydro and steam capacities are available on WPS system

peak-percentage curves will be different; the higher load factors during the war reduced the firm capacity of peaking hydro stations by lengthening the duration of the peaks.

Firm hydro capacity is the load carrying ability of the hydro stations during peak period assuming minimum stream flow conditions. The maximum demands on the power system usually occur in December. The period of greatest deficiency in river flow in Wisconsin was 1933-1934; then the flow as regulated by reservoirs was a minimum. The hydro firm capacity is 43,000 kw, based on the critical month of Decemer 1933. In addition the hydro plants have a reserve of about 10,000 kw, which can be used in emergencies of short duration only; a sustained outage requires steam station reserve capacity.

Steam plant capacity is sometimes reduced by limitation in boiler output or because of high temperatures of the cooling water; with the latter reduction occurring in summer it does not affect the capability in meeting December loads. The capability of the two standby steam plants of Public Service is reduced 30 per cent because

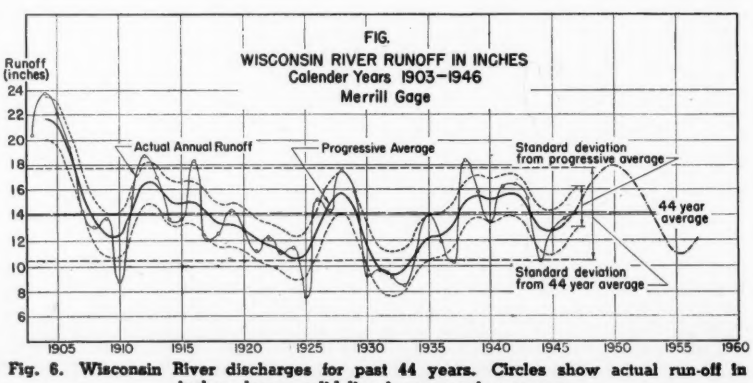


Fig. 6. Wisconsin River discharges for past 44 years. Circles show actual run-off in inches; heavy solid line is progressive average

of insufficient boiler capacity. About 85 per cent of outage time of steam turbines and 90 per cent of the boiler outage time is for scheduled maintenance; only the probability of a forced outage need be considered in determining reserve capacity. The outage time of hydraulic units is about 1 per cent compared to about 10 per cent for boilers, and 6 per cent for steam turbo-generators. With water power capacity already reduced over one-third because of minimum river discharge, further discounting of firm hydro capacity on account of forced outages is unnecessary.

Availability of Steam and Hydro

Figure 5 shows the percentage of time various quantities of hydro capacity on our system are available, compared with the percentage of time various quantities of steam capacity are available on the interconnected utilities in Eastern Wisconsin. About 85 per cent of the steam plant capacity will probably be available 99 per cent of the time. A reserve of 15 per cent appears to be adequate for the interconnected steam plants, with the chances only 1 to 100 of simultaneous outages reducing the capacity a greater amount. While the hydro firm capacity of 43,000 kw is available only 95 per cent of the time, the reduction below the firm capacity occurs outside of the critical month of December.

Storage reservoirs on the headwaters of the Menominee and Wisconsin Rivers retain flood discharges for later release at times of low stream flow. These reservoir systems augment the average water power output about 13 per cent. While the minimum December river flow is increased 80 per cent by reservoirs, the increase in firm capacity is much less, because the firm output of peaking stations cannot exceed the plant capacity.

Coordinated operation of reservoirs and hydro stations requires continuous knowledge of upstream weather and river flow, and anticipation of probable conditions for several days. Hourly and daily hydraulic data are gathered on the headwaters, and transmitted to downstream water powers. Operators have complete information on river, plant, and load characteristics so they can assume responsibility for operating results. From current-meter readings, tables are made showing the most efficient combination of generator loads for each river stage.

Forecasting River Flow

Research to improve and extend forecasts of river flow is underway. The probable spring runoff is estimated from snow surveys. Measurements of soil moisture and temperature are indicative of ground storage in the basin. Statistical analyses indicate the correlation between precipitation and subsequent runoff.

Figure 6 shows the Wisconsin River discharge for the past 44 years; the circles are the actual inches of runoff, while the heavy line is the progressive average. An average flow of 14 in. results from 31 in. yearly precipitation. The standard deviation, measure of the variation in river flow, shows that 2 out of 3 years have a runoff between 10.5 and 17.7 in.; the horizontal dash lines are these limits.

The cyclic form of the progressive average suggests a method of narrowing the limits for estimating the probable river discharge for next year. The standard deviation from the progressive average is the envelope of Fig. 6 above and below the moving average. From this it appears that the chances are 2 to 1 the 1948 river flow will be between 3,000 and 3,700 cfs, which are much closer limits than the deviation from the 44 year average. Based on this and other evidence, it also appears that higher than average river flow will prevail for the next five years, with the runoff expected to decrease after the high in 1950.

CALUMET'S NEW 107,000-KW UNIT GOES INTO OPERATION

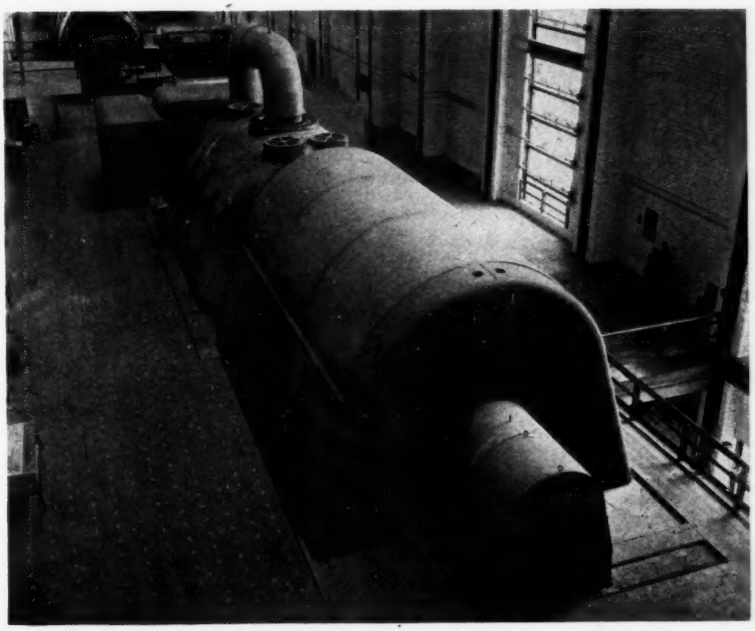
A NEW 107,000-kw turbine generator was placed in commercial operation by Commonwealth Edison Co. on September 18 at its Calumet generating station, 100th St. and the Calumet river, Chicago.

The machine required nearly 30 months for planning, construction and installation since it was ordered from Westinghouse Electric Corp. in March, 1945. Its cost, including the building addition, boilers, transformers, switchgear and auxiliary equipment, was more than $16,000,000.

The new unit is large enough to meet all the electrical needs of a city of 220,000 population. Two Combustion Engineering Co. boilers supply it with steam at 1,250 psi 925 F. They are designed to burn pulverized coal, but can be converted to gas or oil firing.

Installation of the new Calumet unit increases the station's capacity to 294,000-kw and boosts to about 2,400,000-kw the total capacity of the company and its associated utilities, Public Service Co. of Northern Illinois, Western United Gas and Electric Co. and Illinois Northern Utilities Co.

A recently-announced $200,000,000 expansion program will provide for the addition to the power resources of this interconnected system in the next three or four years of still another 407,000-kw, which the companies' surveys show will be required to enable them to supply the growing demand for electricity in the Chicago area. A 150,000-kw unit for Fisk station, and a 107,000-kw unit for the Joliet station of Public Service Co. of Northern Illinois are already on order and studies are being made for the location of a second 150,000-kw turbo-generator. It now takes between three and four years from the time orders are given to get new capacity installed.



View of 107,000-kw Westinghouse turbine generator just put into operation at Calumet generating station of Commonwealth Edison Co., Chicago

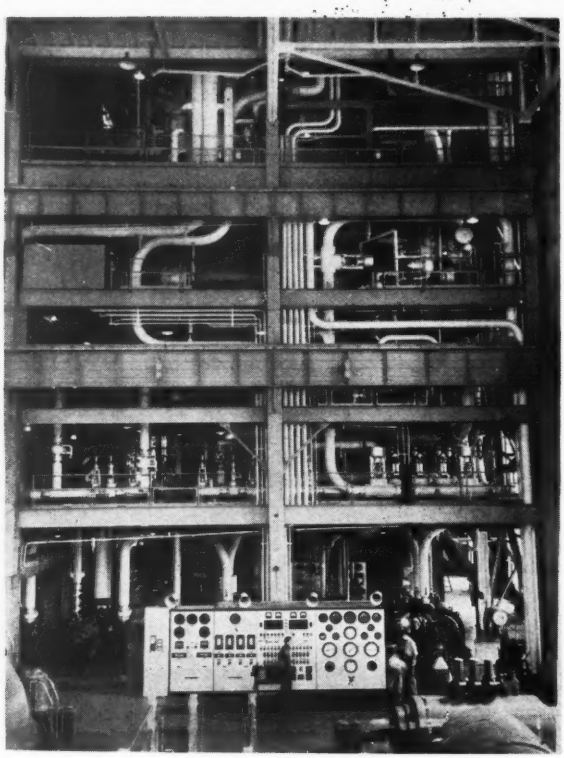


Fig. 1. Auxiliary steam and hot water piping in open galleries between turbine hall and 2500 psi boiler

Six years of satisfactory operation with maximum practical thermal efficiency and a minimum of maintenance . . . Details of insulation on various surfaces described and illustrated . . . Review of station operating characteristics and equipment covered

By H. E. QUICK, *Manager,*
Asbestos, Asphalt and Insulation Mfg. Co.

Insulating a 2,500 Psi Steam-Electric Power Unit

THE ONLY power plant in the country with a boiler operating pressure of 2500 psi and a steam turbine operating pressure of 2300 psi is the high pressure power generating unit at the Twin Branch plant of the Indiana & Michigan Electric Company which is part of the Central System of the American Gas & Electric Service Corporation. The unit was first put into operation in March, 1941.

An important phase of the design and construction of the unit was the insulation of the steam generating unit, turbines and auxiliary equipment. Six years of satisfactory operation, with maximum practical thermal efficiency and a minimum of maintenance, have demonstrated the effectiveness of the insulating materials and techniques employed.

The natural circulation Babcock & Wilcox boiler unit consists of a primary furnace, first and second open pass, main and by-pass convection section, economizer and air heater. The boiler differs from the conventional open-pass design in that the side walls of the first open pass and second open pass are covered with reheat surface. The division wall between the first and second pass is made up of steam generation surfaee, while the division wall between the second and last pass is reheat surface.

The last pass of the boiler contains initial superheater, reheat and economizer surfaces, the reheater section being placed apart from the superheater and arranged for reheat control by means of baffles and by-pass damper. An attemperator (five-spray nozzle-type desuperheater) capable of reducing the temperature of the initial superheat approximately 100 deg is located in the piping between the convection and radiant superheater stages.

Coal is pulverized by four type E, size 53 mills, and oil burners are used for coal ignition. Primary air to the four mills is supplied by one primary fan having a capacity of 38,600 cfm at 25-in. static pressure; secondary air is provided by one forced draft fan having a capacity of 153,000 cfm at 11.6-in. static pressure; and induced draft is provided by two fans, each having a capacity of 170,000 cfm at 365 F, 17.8-in. static pressure, at 870 rpm.

The boiler has an operating pressure of 2400 psi at the superheater outlet, and a final temperature of 940 F at a flow of 550,000 lbs/hr. Steam is returned from the high pressure turbine to the boiler for reheating at a temperature of 545 F at a flow of 440,000 lbs/hr and goes to the low pressure turbine at a temperature of 900 F.

The cross-compound turbo-generator unit consists of a 22,500-kw high pressure unit, operating at 3,600 rpm with a 2,300-psi throttle pressure, and a 54,000-kw low pressure unit, operating at 1,800 rpm with a 330-psi inlet pressure, both machines being hydrogen-cooled.

There are three Ingersoll-Rand high pressure boiler feed pumps rated

All drawings indicate the general manner in which insulation was applied to the various elements at Twin Branch plant. Editor.

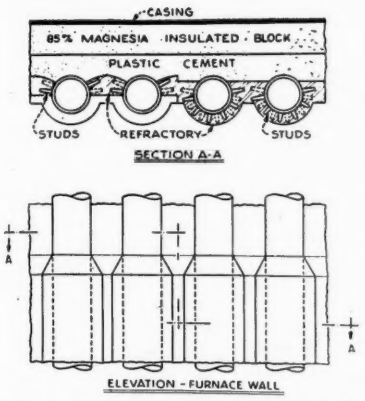


Fig. 2. This is the method followed in insulating flat surfaces such as furnace or reheater walls

at 1,230 gpm, 340 F and 2,800-psi discharge pressure. The boiler feed pumps are supplied with water by two tank pumps rated at 1,275 gpm, 262 F and 50-ft net positive suction head. The compactness of the plant is indicated by its cubage per kw capacity, which is less than 25 cu ft.

Insulating Materials

The insulating material for all piping systems and equipment operating at temperatures up to 600 F was specified as 85 per cent Magnesia. For temperatures above 600 F, the specifications called for a combination of materials consisting of an inner layer of a diatomaceous silica type of insulation and an outer layer of 85 per cent Magnesia. The high temperature insulating material is applied directly to the equipment to be insured in a thickness sufficient to bring the temperature at its outer surface to around 600 F and then the 85 per cent Magnesia is applied.

The method of applying the insulation to all flat surfaces such as furnace or reheater walls was basically the same. First a high temperature insulating cement was applied (in some instances over a layer of refractory cement) in a thickness sufficient to cover all projections, such as studs, bolts, tubing, etc., and form a smooth surface. Then a layer of high temperature insulating block and a layer of magnesia block were applied in a staggered joint arrangement and each layer was tightly laced against the surface by means of annealed wire attached to bolts provided for the purpose. All blocks were closely butted together as they were applied and the joints between the blocks were pointed up with cement. The lacing wire was crisscrossed so that each block was held firmly against the cement with no voids.

Where a cement finish was desired for appearance and for protection of the insulating block, hexagonal mesh wire, instead of the annealed wire, was used over the outer layer as a base for a layer of insulating cement.

For the primary furnace floor, no blocks were used. Instead, after the high temperature insulating cement was applied, a layer of expanded lath was forced hard against the cement by means of washers and alloy speed nuts. A second layer of cement was applied and covered with metal lath. A third layer of cement in which a layer of expanded metal lath was imbedded was applied while the boiler was under pressure. The surface was finished with hexagonal mesh wire covered with insulating cement. The same procedure was used for insulating the reheater floor within the vestibule, except that an initial layer of refractory cement and only one layer of high temperature cement and one of expanded metal lath were used.

Whenever a surface was finished with insulating cement, expansion grooves were cut while the last coat of cement was still soft to avoid cracking of the finished surface.

All steam headers were insulated with a layer of curved high temperature insulating blocks, and in most cases with a second layer of curved magnesia blocks. Each layer of block was secured to the header with either annealed market wire or soft steel bands that were attached to angle sections welded to the header for

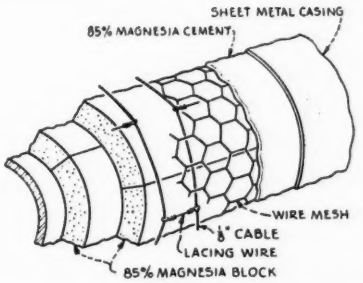


Fig. 3. Steam headers at the Twin Branch plant were insulated in a manner similar to this

that purpose. The entire insulation was then reinforced with hexagonal mesh galvanized wire. Where the insulation was not covered with a metal casing, a coat of insulating cement was applied to the mesh wire.

All risers, piping and tubes that were covered individually were insulated with a layer of high temperature sectional pipe insulation and a layer of magnesia sectional pipe insulation, each layer being bound in place with annealed wire. The insulation was then covered with rosin-sized paper and a canvas jacket.

Closely spaced tubes, such as the exposed portion of division wall tubes, were enclosed in a layer of high temperature insulating block followed by a layer of magnesia block, and then covered with hexagonal mesh wire and insulating cement. In some cases the mesh wire was omitted and expanded metal was substituted, for greater insulation protection. A removable section of insulation, approximately 16 in. by 18 in., was provided in the middle of the boiler to allow for periodic inspection of the tube seats without causing damage to the insulation.

In the case of the exposed portion of the lower drum, the down-comer pipe, and the exposed portion of the upper drum, expansion joints were provided in both the inner high temperature and the outer magnesia block layers. The expansion joints were spaced about 4 ft apart and those in the outer layer were staggered with those in the inner layer.

The flue between the economizer and the air heater, the flue between the air heater and the induced draft fan, and the top of the air heater were insulated with a layer of magnesia blocks, the application procedure being the same as used on all the other flat surfaces. Either a canvas jacket or a coat of insulating cement applied over hexagonal mesh wire was used as the finish.

Where primary and secondary air ducts were insulated externally, road mesh was first spot welded to the stiffening members of the duct. A layer of magnesia block was then applied to the mesh and tied with suitable wire cables. The road mesh and insulation were applied so that the full thickness of insulation covered all buckstays and stiffening flanges. This procedure was followed so that an air space, equal to the depth of the stiffening members between the duct and the back of the road mesh, would be provided to protect the duct metal from being burned through at "hot spots."

Where the air ducts were insulated internally, a layer of magnesia blocks was bonded to the inside surface of the duct with asbestos adhesive cement. In addition, the blocks were held in place by means of perforated hangers fitted over stove bolts welded to the inside of the ducts. The blocks were covered with expanded metal

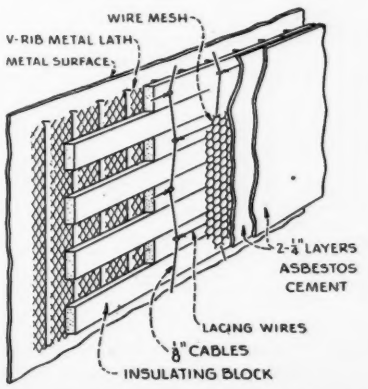


Fig. 4. Flue exteriors were insulated like this

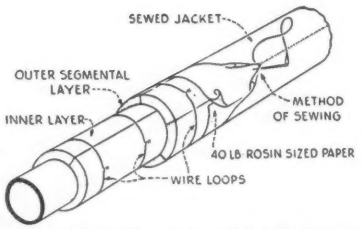


Fig. 5. All pipes, up to and including 10-in., were insulated as shown on this drawing

lath secured to the hanger irons with annealed wire, and finished with a coat of semi-refractory cement.

All pipes up to and including 10-in. nominal diameter were insulated with a single layer or a double layer of magnesia semi-cylindrical pipe insulation or an inner layer of high temperature insulation and an outer layer of magnesia, depending upon the temperature of operation. Insulation for piping 12 in. in diameter and over and on all bends consisted of segmental pipe insulation molded to fit the circumference of the pipe.

Each layer of insulation was wired in place and all joints and cracks were filled with cement made of the same material as the covering, i.e., either high temperature or magnesia cement. The piping was then wrapped with a layer of rosin-sized paper and followed by a sewed canvas jacket.

Pipe insulation was cut back near valves, fittings and flanges, to permit withdrawal of flange bolts, etc. The ends of the insulation were beveled and sealed with cement of the same material as the covering. To provide supports for the insulation where it was at least 2 in. thick, lugs were welded on all vertical risers 40 ft or more in height.

Flanges were not insulated until the pipe lines on which they were situated had been in service long enough to indicate that all pipe joints were tight. Then they were insulated with either blocks or cement of the same insulating material and in the same thickness as the adjacent piping. The insulation was reinforced with a layer of galvanized mesh wire which in turn was covered with two layers of insulating cement, the second layer consisting of a mixture of asbestos and portland cement. A canvas jacket was then pasted on.

All valves, fittings, and specialties were insulated in the same manner as the flanges, except that valves on piping 3 in. and smaller were insulated entirely with cement instead of blocks. Equipment insulation was similar to that of piping except that blocks were used instead of semi-cylindrical or segmental insulation.

When insulation was applied to heaters and other equipment with bolted or screwed heads that must be removed from time to time for inspection and repair, the fastenings were left exposed and the insulation was applied in such a manner that it would not be damaged by the removal of the bolts, screws, heads, covers or plates. To accomplish this, a brass or iron angle was attached inside the bolt circle to form a stop or toe so that the insulation could be finished off. Name plates on all equipment were removed and reinstalled on the insulated surface.

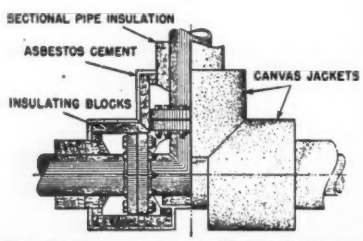


Fig. 6. Permanent type flange insulation was applied after the flanges and pipe lines had been in service long enough to determine whether or not all joints were tight

PROPERTIES OF 0.5% CHROMIUM 0.5% MOLYBDENUM PIPE STEEL

By R. C. FITZGERALD[1], A. B. WILDER[2], G. V. SMITH[3], and A. E. WHITE[4]

SINCE THE OCCURRENCE, early in 1943, of severe local graphitization and failure of a welded joint of Molybdenum steel in a high pressure steam line at the Springdale Station of the West Penn Power Co., considerable effort has been expended by metallurgists and engineers in attempting, on one hand, to gain an insight into the fundamental factors involved in the reversion of carbide to graphite, and on the other, to develop alloys and manufacturing practices which will inhibit the formation of graphite during commercial usage.

Of the several changes proposed to minimize or prevent graphitization, that involving the alloying addition of chromium has generally been considered to be the most efficacious means of accomplishing this end. The cooperative study reported before the ASME annual meeting, December 1947, was undertaken to test this possibility. An arbitrary chromium addition of 0.5 per cent (to the 0.5 per cent Molybdenum level commonly used for steam pipe) was selected. Since this investigation was started in July 1944, ASTM specification A280-46aT relating to Seamless Chromium-Molybdeum Alloy Steel Pipe for Service at High Temperatures has been introduced. The chemical analysis of the steels studied lies within the scope of this specification.

Two heats of commercial size, which cannot always be approximated by small experimental or laboratory heats, were employed for the tests. These were rolled into 10-3/4 in. O.D. by 1.125 in. wall seamless pipe. The two heats were nominally identical except for the deoxidation practice employed, one being made to coarse-grained, the other to fine-grained practice. The coarse-grained heat was deoxidized with silicon only, i.e. no aluminum, while the fine-grained heat was deoxidized with 1-1/4 lb of aluminum per ton of steel in addition to a prior silicon addition. Study of the influence of deoxidation practice was dictated by the important roles which aluminu mplays in the service of steel at elevated temperature. A large addition of aluminum results in fine grain size which, though beneficial to toughness and freedom from embrittlement, is generally considered detrimental to creep strength. In recent years, a large aluminum addition has been clearly proved to contribute to susceptibility to graphitization. Yet the use of at least some aluminum is quite desirable from the purely mechanical aspects of steel processing to obtain desirable surface quality and thus economy of manufacture.

Results may be briefly summarized as follows:

1. The mechanical properties of this material at ordinary temperature are at a slightly higher level than in the plain molybdeum steel.
2. Satisfactory flattening and etch tests of the pipe may be expected.
3. Welding electrodes have been developed which will satisfactorily deposit 0.5 per cent Mo weld metal containing either of two levels of chromium content—0.35 and 0.5 per cent—with properties similar to the base metal.
4. Satisfactory procedures are available for welding this material under commercial conditions. These involve preheating at 500 F. as well as post heating at 1300 F.
5. Bending and upsetting tests indicate that this material may be fabricated as readily as other material.
6. The results of residual stress measurement are presented.
7. The material possesses adequate scaling resistance for the contemplated se rvice range of temperature.
8. Hardness and notch-impact tests before and after exposure at elevated temperature indicate that no deleterious embrittlement may be expected.
9. Extensive studies have failed to show graphitization in this material, however deoxidized or initially—or post-treated, when exposed up to 15,000 hrs at 1025 F or 12,000 hrs at 1100 F.
10. The creep strength of this grade of steel is comparable to some of the low chromium, low molybdeum types of steel.
11. In the as-rolled and stress-relieved condition, Heat X11647, to which was added 1.25 lb of aluminum per ton of steel, had the higher creep strength, while in the normalized and stress-relieved condition, Heat X11648, to which no aluminum was added, had the higher creep strength.

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The PRACTICAL ENGINEER

DEVOTED TO PLANT OPERATION and MAINTENANCE

A. W. KRAMER, EDITOR

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ENCARNADINED VISAGE (RED FACE, TO YOU) DEPARTMENT

Here we are again with our editorial faces the color of that Canal No. 7 stuff the gals use to bloody up their fingernails.

This time it's about our Super Q & A section—November issue, pages 87 and 95, December issue, page 98.

When we received the questions and answers that were published under the heading One Horsepower Questions with High Pressure Answers, they did not look familiar to us. They were submitted in complete good faith by a reader to whom they were given, all typed out, by a local boiler inspector. But he did not recognize them and neither did we.

Now, readers inform us that they are nearly word for word like those in a little book of the same title published in 1937 by the late George H. Wallace, for years a Nordberg erecting engineer.

At the time, we did not have a copy of Mr. Wallace's booklet in our library (we have now obtained one) and we cannot account for that, because we knew Mr. Wallace well. He used to call here at the office frequently to tell us fascinating tales of men and methods he encountered and used all over the world in his erecting jobs. Many of these tales found their way into *Power Plant Engineering* over the years. That's why we are puzzled we didn't recognize Mr. Wallace's questions and answers.

If we had, we certainly would have credited them to Mr. Wallace. Mr. Church didn't know, either, that they were Wallace's.

But it's our job to catch things like that, and we certainly booted this one. Many readers probably have Mr. Wallace's little book and if they noted this fumble of ours, we hope they'll forgive us for letting it slip through. George Wallace was such a great guy and so well known in the field that we must do all we can to give him full credit for the One Horsepower Questions with High-Pressure Answers.

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Simplified Electrical Equipment Maintenance

Importance of electrical equipment maintenance . . . Planning maintenance schedules . . . Use of diagrams in electrical equipment maintenance . . . Training of Maintenance Personnel . . . Types of electrical equipment

By TAYLOR BASKIN

THE MAINTENANCE OF plant electrical equipment can be made considerably easier if certain simple methods are followed. These are based essentially on the theory that regular preventive maintenance is both easier and cheaper than neglect. True, where electrical equipment is allowed to run day after day without attention, the maintenance crew are given an opportunity to take things easy, and there is no expense for lubricants, renewal parts, etc. But such a situation can go on for just a certain length of time. Then will come the penalty period. Bearings will burn out, commutators and slip rings will burn and pit, motor windings will fail, and then the hard, (and expensive) work will begin. And it will be found that probably ten times as much back-breaking toil will be required to repair than would be necessary for maintenance. Who benefits then? The worker? The owner? No. The fact is nobody benefits.

But sound maintenance will produce benefits for all. Operating expense will be kept at a minimum, and the maintenance crew can perform their duties in a careful and unhurried manner.

Fig. 1. Tightening contact segments on motor starting rheostat

Of course, such a program will require a plan which must be strictly followed. Cutting corners will not help matters because it will only result in additional work later on. But the more carefully the maintenance schedule is followed, the easier will be the task of maintenance.

The first requirement for an efficient system is to provide a card or loose-leaf index of each piece of electrical equipment. These records should cover all necessary information, such as nameplate reading, application, location, date of installation, type of lubrication, size, type and number of brushes (if any), and such other information as will simplify the ordering and stocking of repair and renewal parts and supplies.

The second necessary requirement is a simple inventory system for parts and supplies that will provide a constant visual reminder of the stock conditions. This can easily be accomplished by placing small cards or tags with each type of material, and noting on them the name of the article, the number required for stock, and the number on hand. The number on hand should be changed whenever items are removed from, or added to stock.

A third necessity is a set of parts lists or catalogs arranged to simplify ordering of parts and maintenance of stock. The simplification procedure should include lists of parts duplicated on various equipment. This eliminates the chance of duplicate parts being ordered in greater quantities than necessary.

The fourth required provision of this plan is a combination maintenance and lubrication chart. This should be so arranged that a comprehensive but simple record of the lubrication requirements of each machine be included, as well as a record of both lubrication and maintenance checkups, and by whom made and when.

Other refinements to this system could include records of repairs, replacements, reinstallations, etc.

It is highly desirable to have as complete a set of blueprints or diagrams of the equipment as possible. If these are not available, it may be possible to obtain them from the manufacturers. Diagrams are very helpful when trouble develops and it is necessary to check circuits. Even such simple circuits as motors and starters are made even simpler by reference to diagrams.

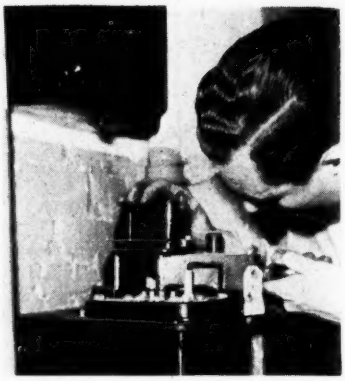

Fig. 2. Examining operation of a drum controller

A maintenance crew, equipped with such systematic aids as suggested here and carefully following a regular routine, will be able to maintain the equipment in better condition with less effort. Repairs will be minimized, and expensive shutdowns, resulting in loss of revenue or production, will, in great measure, be eliminated.

Of course, it is vitally necessary to the success of any maintenance plan that each man be trained to do his job skillfully and efficiently. In small plants it is likely that the maintenance man will take care of lubrication, inspection and maintenance. But in larger plants, where the employment of separate maintenance men for these various tasks is economically justifiable, each man should be individually trained for his particular job. This training should be both theoretical and practical. The man entrusted with lubrication should not merely know enough to add oil or grease to a bearing. He should advisedly be taught the simple principles of lubrication, the characteristics of various grades and types of lubricants, the lubrication requirements of each kind of bearing and the necessary variations in these requirements due to service and location conditions, how to detect faults in bearing performance, how to flush and refill bearings, and how to check bearings to determine whether they are operating properly.

Likewise the workman given the responsibility for keeping the equipment clean should be trained to know why this is necessary, to know what cleaning agents should be used and how, and to know how to avoid damaging the equipment while cleaning it.

And, of course, the mechanic assigned to examine the equipment and make repairs where necessary should be especially qualified for this work. His training should include a thorough

grounding in the theory and practical operation of electrical equipment of the type on which he is to be employed. This training should include the use of testing instruments for locating sources of trouble as well as for making routine checkups, the replacement of brushes, contacts, coils and other parts, the dismantling and assembling of apparatus, and the repair of defective equipment.

In order to intelligently maintain electrical equipment in good operating condition it is necessary to know what this implies. A motor, for instance, may be running smoothly, be clean and showing no evidence of distress, yet the bearings may be worn sufficiently to permit the rotor to pole before the next inspection. This is why it is definitely necessary to give each piece of equipment a careful and complete checkup at each periodic inspection. The apparatus should, of course, be clean, free from dust, and all parts should be in place and secured. The temperature rise of windings and other parts should be within the manufacturer's specifications. Levels of lubricants and insulating oils should be checked, lubricant seals should be examined for escape of lubricant or lubricant vapor. If lubricant seals are defective they should be replaced, as oil and grease are detrimental to most insulations.

What to Look For

In examining motors, check slip rings, commutators, brushes, brush holders, slot insulation, field coil fastenings, rotor end play, and bearing lost motion or running sounds. Slip rings or commutators showing evidence of roughness or burning should be resurfaced with a resurfacing tool or resurfacing stone. Sticking brushes or sluggish brush holders should be remedied and made to operate correctly and smoothly. Worn brushes should be replaced with new ones. Commutator and slip rings should be free of grease, dirt, and oil, and the insulation should be in good condition. The armature (or rotor) and stator windings should be secure and well insulated. End play should not be excessive, and it should be ascertained that existing end play is such as to not permit the brushes to run off the commutator or slip ring surfaces. Where the bearings are of the ball or roller type, these should not be noisy or show indications of roughness. Sleeve bearings should be checked for excessive wear in both the vertical and horizontal directions by measuring the air gap between rotor and stator with a feeler gauge. Due to the small air gap in a-c motors, bearing wear must not be permitted to become excessive. It is also very important to check the operation of ring and chain oilers on sleeve bearings. If these fail to rotate for any reason the bearing will be deprived of its required supply of oil and serious wear will result.

Electrical control apparatus varies from simple to complex and so does its maintenance. The most vulnerable parts of starters are generally the contacts. These require smoothing with a file when they are burned or roughened. If they are in too bad a condition to be resurfaced they should be replaced. Some contacts are made of silver. These usually do not require filing as the oxides that form on their contacting surfaces are conductors of electricity.

Coils, resistors, springs, shunts, and other parts should be examined for wear or deterioration. Any found sufficiently defective to be detrimental to operation should be replaced. The judicious application of a volatile graphite lubricant to frictional points may be helpful in providing smooth operation and reducing wear, but oil or grease should not be used, as this will cause dust to collect and render the operation sluggish.

Air dashpots should be cleaned with a cloth dipped in carbon tetrachloride. The liquid in an oil dashpot should be drained and the dashpot flushed out with carbon tetrachloride. The liquid should then be filtered and returned to the dashpot, and any required additional amount should be added.

The operation of each starter should be checked by hand, if possible, with the current off, then by electricity to determine whether it functions properly.

Automatic timers and other types of control may require additional procedures. Some may have parts that require lubrication with special oil.

Push buttons, lever switches, limit switches, drum controllers and similar apparatus require checking to determine whether they are in need of attention, but, except for manual switches that break large currents, these devices seldom give trouble and their maintenance is usually limited to checkup, and possible lubrication on certain types.

To prevent the necessity for making needless trips back to the shop for parts, tools or supplies, a sufficient assortment of these needed articles should be taken on the tour of inspection. Where the quantity of materials justified, and especially if lubricants must also be carried, it is well to employ a small wheeled truck to transport the materials and equipment from job to job.

Where inspection shows that a piece of electrical equipment is in need of servicing, if this work cannot be done at the time without seriously disrupting production or other schedules, it is advisable, where possible, to make temporary repairs and arrange for permanent repairs to be made at a

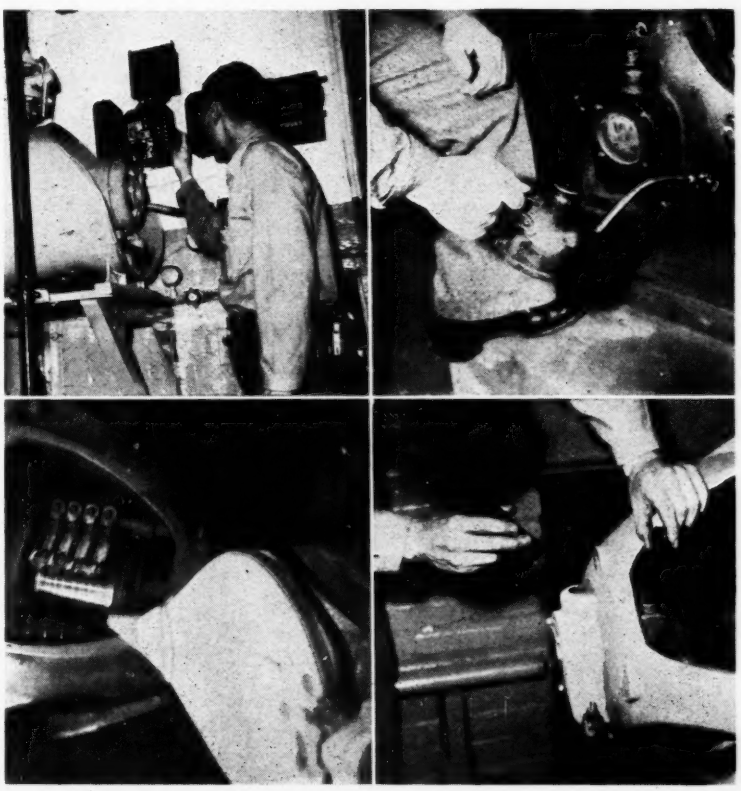

Fig. 3—Upper Left: Checking operation of an automatic motor timer. Fig. 4—Upper Right: Replenishing oil in motor bearing oil reservoir. Fig. 5—Lower Left: Blowing dust from generator set. Fig. 6—Lower Right: Examining motor bearing oil ring

time when the equipment can be shut down.

Needless to say, no electrical equipment should be inspected or worked upon while the current is turned on. Be sure that the line switch is open and, if necessary, locked in open position, and that you have the keys in your pocket. It is very easy for someone to forget that the apparatus is out of service, and to close the switch. Serious burns or shocks, and even death, can result through neglect to carry out this precaution.

Diesel Lubrication

Lubrication requirements . . . Lubricating systems force feed, pressure circulating . . . Physical . . . Force feed properties of lubricating oils . . . Additives . . . Impurities . . . Purification . . . Settling . . . Centrifuging

GOOD LUBRICATION, vitally important in any mechanism, is especially important in Diesel engines because of the close clearances and high pressures inherent in their design. The life of the engine, its dependability of service, and its efficiency are dependent upon the effectiveness of the lubricating system and the quality of lubricating oil used.

The components of a Diesel engine which require lubrication may be divided into the following groups:

1. Pistons and cylinder walls.
2. Bearings, (crankshaft, connecting rod, wrist pin).
3. Air compressors for injection or scavenging.
4. Power train for transmitting motion to auxiliaries.

Types of Lubricating Systems

Three general types of lubricating systems are found in modern Diesel practice: 1, The mechanical force feed system; 2, The pressure circulating system; 3, A combination of the two. As a rule, slow-speed engines employ two independent systems of lubrication while high speed engines employ only a single lubricating system.

In the mechanical force feed lubricating system oil is supplied by an individual pump and supply line to each point lubricated, and its main advantage is the accurate manner by which the rate of application to each point can be controlled. This attribute makes it especially adaptable to cylinder lubrication for large engines and for crankcase-scavenged two-cycle engines where excessive oil vapors in the crankcase are objectionable. See Fig. 1.

Pressure Circulating Systems

Pressure circulating systems circulate a generous stream of oil continuously to all parts of the engine except the cylinders which are lubricated by throw-off from the connecting rods. Oil passageways drilled in the block afford better circulating system than do oil lines since they are less likely to develop leaks. Drilled connecting rods and crankshafts are the usual practice.

The oil pump draws oil from a crankcase sump or storage tank and pumps a quantity in excess of that needed for lubrication. The added circulation provides for piston and bearing cooling and for the extra circulation necessary to compensate for bearing wear or the thinning effect which fuel dilution has on the lubricating oil. Oil pressure is automatically regulated by a by-pass valve usually located in the oil pump housing.

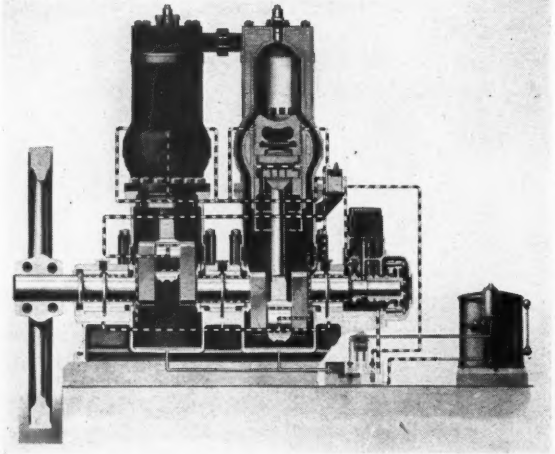

Fig. 1. Mechanical force feed lubricating system employed in a two-cycle crankcase scavenged engine. The ring oilers are employed for the main bearings. This is a dry pump engine because an excess of oil vapors accumulating in the crankcase might cause the engine to overspeed by entering the combustion chamber. (Courtesy, Fairbanks, Morse & Co.)

Combination Systems

Where two independent lubricating systems are used, the force feed type is used to lubricate the cylinders and pistons, and a pressure circulating system is used for lubricating all other working parts of the engine (main bearings, crankpins, connecting rod bearings, governor and fuel pump bearings). Fig. 2.

Physical Properties of Lubricating Oils

Many of the characteristics of fuel oils are also applicable to lubricating oils. Certain additional qualities are desirable, in addition to viscosity, pour point, carbon residue and flash point, and must be considered in selecting a lubricating oil. These, with brief definitions follow:

Oxidation resistance: The ability of an oil to resist oxidation when heated and exposed to air.

Corrosion resistance: The action which an oil has on a test specimen of bearing metal when agitated and heated is a measure of its corrosion resistance.

Detergency: That characteristics of an oil which prevents combustion and oxidation products from depositing out. In dirty engines a detergent oil will dissolve previously formed deposits.

Dispersion: That characteristic of an oil which allows it to keep finely divided insoluble particles in a suspended state.

Foam stability: The time required for foam to disappear when the oil is agitated with air. The longer the foam stability the less desirable the oil, other things being equal.

Extreme pressure characteristics: The ability of an oil to stand up under extremely high pressures, measured by the film strength of the oil.

Reaction with water: It is desirable that the oil separate readily from water.

Homogeneity: An indication as to the likelihood of the additives separating from the oil throughout the operating range of temperatures.

Compatibility: An indication as to whether the additives might separate from the oil when two different oils are mixed. This quality must be determined by test before an oil different from that in the engine is added.

Additives

Often small percentages of various oil soluble compounds are added to lubricating oils in order to impart characteristics which are not obtainable through the refining process. These compounds, called additives, are of several types, each designed

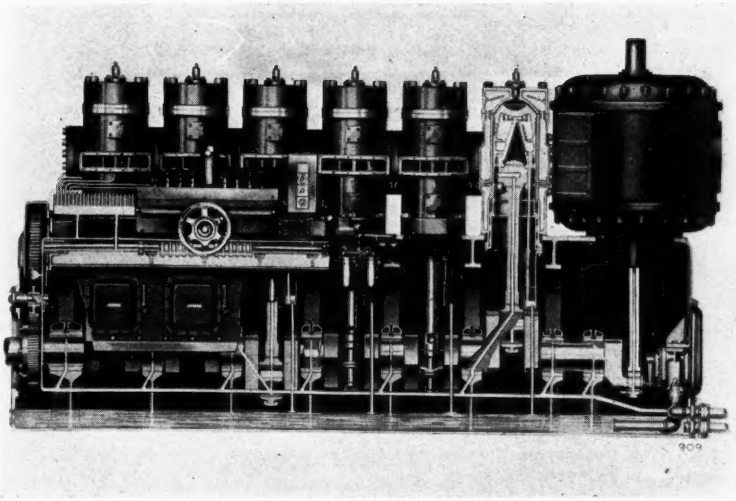

Fig. 2. Lubrication system details of a two cycle solid injection Diesel engine. A combination of mechanical force feed and pressure circulating systems is used. (Courtesy, Fairbanks, Morse & Co.)

to perform a certain job. Included are:

1. Oxidation inhibitors, to prevent sludge, varnish and bearing corrosion.
2. Detergents, to keep engine surfaces clean.
3. Dispersants, to keep potential sludge deposits in suspension.
4. Extreme pressure agents, to reduce engine wear and prevent scuffing by forming a lubricating film which prevents metallic contact when oil is forced out from between rubbing surfaces.
5. Rust preventatives.
6. Other additives are sometimes used to lower the pour point, improve the viscosity index, or to lower the foaming tendency of an oil.

Lubricating Oil Impurities

Lubricating oil used in a Diesel engine is continually subjected to contamination while the engine is in operation. It picks up carbon from the cylinders, water, dust, bits of metal, and other impurities from the atmosphere or as a result of improper handling. The chemical composition of the oil may change as a result of high temperatures encountered and acidic impurities present.

Some of these impurities are deposited in the engine and the remainder are carried in suspension in the oil. The exact proportion that is carried in the oil varies with the engine, operating conditions, and the type of lubricating oil used.

In order to keep the contaminants in the oil from damaging the engine it is necessary to either change the oil often or purify it in some way. The latter is the more economical way.

Various methods of purification are used, and no one method is suitable for all oils or operating conditions. Each method has its advantages and the choice must be based on a number of considerations, including type of oil used, quantity used, degree of contamination, type of contamination, plant layout, etc.

Methods of Purifying Oil

Three basic methods of purifying lubricating oil in common use today, are settling, filtering, and chemical reclaiming. Often combinations of these methods are used. Reconditioning may either be done as the oil is used in the engine by circulating part of it through a reclaimer of some sort, or by the batch method where the old oil is removed from the engine, put through the reclaiming process, and then replaced in the engine. When the one batch is removed another replaces it in the engine, of course.

The simplest method of oil reclamation is settling. The oil is removed from the engine, placed in a tank heated, and allowed to stand for a certain length of time, and the carbon, water and other impurities settle to the bottom of the tank. The renovated oil at the top is removed and is ready to be used in the engine again.

Inherent disadvantages in this system are that the oil must be removed from the engine and stored in a tank for a period of time. In an engine which uses a large quantity of lubricating oil the settling system would be objectionable because of the considerable storage space needed for reclamation.

Caution must be exercised in heating the oil since lubricating oils oxidize at a high rate when heated over 200 to 225 F.

Centrifuging

Centrifuging is in actuality an accelerated settling process, wherein oil is whirled at high speeds and the force exerted on the contaminants is several thousand times the force of gravity, the time of reclamation being much shorter as a result. All solids and liquids which are heavier than the oil and not in solution in the oil will be removed by centrifuging.

In some instances, water is heated and added to the oil before centrifuging, in order to dissolve certain acid impurities in the oil and carry them away. This process requires considerable skill and the operator must be careful in the operation to make certain the water is all removed, and that the water added to the oil is free from impurities.

Centrifuges may be installed to handle a portion of the flow of oil through each of several engines, thus having a continuous purifying system which is preferable to the batch method.

Filtering Diesel Lubricating Oils*

Filters are probably the most widely used of all oil purification methods, since they are economical and readily applicable to small engines. Filtering media used may be divided into two general categories, absorption and adsorption types. Inert materials such as cotton waste,

*See POWER PLANT ENGINEERING, April, 1947. "The Filtration of Diesel Lubricating Oils," by J. A. Nelson.

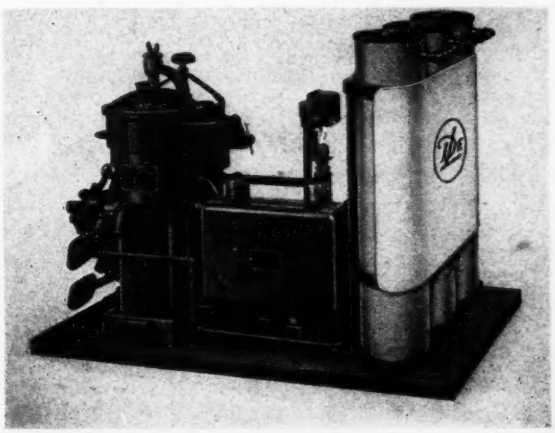

Fig. 3. Combination centrifuge and filter unit with dirty oil and clean oil pumps. The centrifuge removes the water and acids and heavier solids, the filter removes fine suspended solids

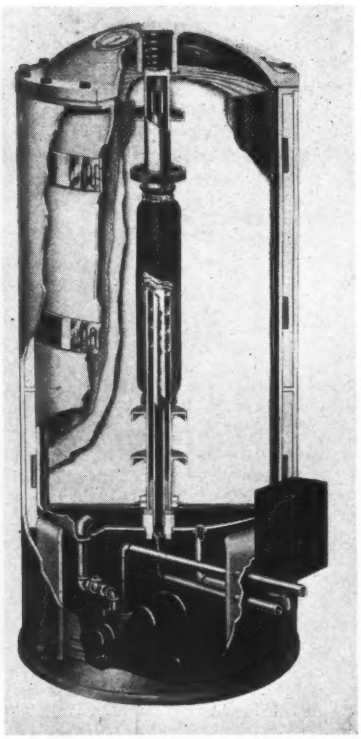

Fig. 4. Continuous oil purifier employing a single bulk type of refill (processed fuller's earth) as the purifying agent. (Courtesy, Honan-Crane Corp.)

paper, in fact cellulose in any form and inert diatomaceous earths are in the first category. Adsorption type media include such materials as Silica Gel, Fuller's Earth, etc., as in Fig. 4.

Two general systems of oil filtration are in common use today, namely, the shunt system and the by-pass system. Both are shown in Fig. 5. When the shunt system is used the filtering element is installed in parallel with an automatic pressure relief valve which maintains a constant pressure drop across the filter element. This system requires a larger filter capacity per unit of engine size, but it also keeps the oil cleaner for a longer period. For comparison see Fig. 6.

The by-pass system bleeds off a portion of the oil, passes it through the filter and returns it to the crankcase or sump. Formerly it was believed that the slower the oil passed through the filter, the cleaner it came out, but this theory has been disproved by extensive tests, and the belief at present is that high flow rates subject the oil to filtration a greater number of times per hour of operation and result in cleaner oil.

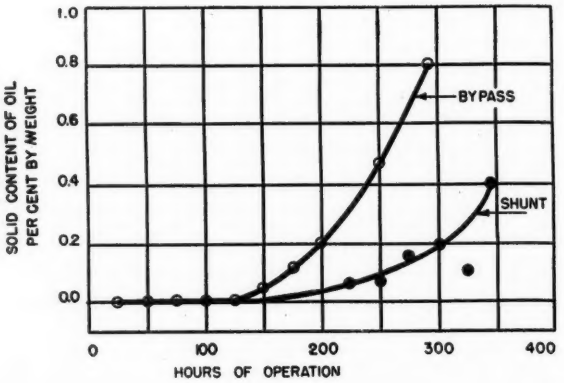

Fig. 6. A comparison chart of bypass and shunt operation for lubricating oil filters

Chemical Reclaimers

Essentially these units employ a redistillation process followed by filtration through an adsorbent-type filter. This type of reclaimer must be selected with great care, since their correct operation depends on the type of oil, to be processed, the method of applying heat, types and strength of chemicals used in the reclaimers, etc. These units as a rule are costly to operate since the cost of chemicals used and electricity for heating is considerable.

Oil Coolers

Diesel lubricating oil picks up a considerable amount of heat when circulating through a heavily loaded engine, and often the heat loss by radiation from the oil to the cooling system and atmosphere may not be enough to keep the oil temperature within a good working range (145-180 F). In this case it is necessary to use an oil cooler which is merely a heat exchanger. Thermostatic controls are usually employed to keep the oil by-passing the oil cooler until the engine is warmed up.

(Ed. Note: This is the third of four articles on Diesel engines and their care. The fourth and last article will deal with laying out the Diesel generating plant.)

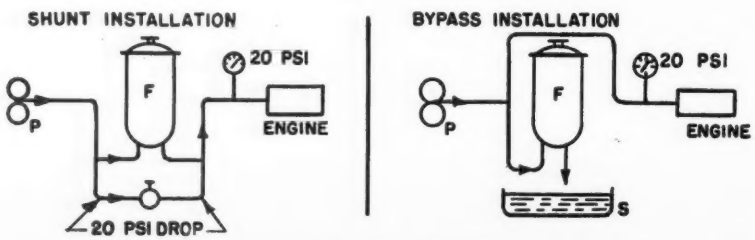

Fig. 5. The two general systems of hooking up oil filters
P—Lub Oil Pump; F—Filter; S—Sump

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TRANSFORMER OPERATION AT OVER-VOLTAGE

By C. O. von Dannenberg

THE DESIGN of the modern transformer is such that its operation at voltages higher than the rated value will result in:

1. Higher no load losses in watts.
2. Greatly increased exciting currents.

The higher no load losses in watts will result in increased values closely proportional to the square of the ratio of higher to the lower value. This is true through test results to 10 per cent increase in applied voltage.

The exciting current however due to the design elements, particularly the magnetic density used and associated elements will vary at a higher rate than the square of the ratio even for 10 per cent increase in the applied voltage. Analyses of a number of tests indicate the ratio to be close to two (2) for a 10 per cent increase. Assuming for discussion the ratio 2 then the increase can be shown by a general formula.

$2 = (1.10)^X$ where X can be shown to be 7.3 or as otherwise expressed as the 7.3 power of the impressed voltage ratio. This indicates of course that the magnetic saturation is beyond the "bend" of the region where its increase is in the direct proportion to the induced voltage resulting in a "straight line" result.

The preceding discussion is of much more importance when the impressed voltage exceeds the rated voltage to a higher degree. Assuming the normal exciting current to be

2 per cent and its increase to be proportional to the 7.3 power of the impressed voltages what voltage would cause an exciting current to flow equal to the full load voltage? The formula can then be written

$$50 = (X)\ 7.3 \text{ or } X = 1.75$$

or 15 per cent over voltage.

An actual experience was a situation where a transformer bank was connected in delta, on the line side, where it should have been connected in star hence each winding had impressed upon it a voltage of 73 per cent in excess of its rated value and in this instance the transformers all failed indicating the calculated exponent of 7.3 to be too low for the particular transformers concerned. What the exciting current might have been is yet to be revealed but the failure indicates without argument what a high value it may have been. All authorities consulted have not even revealed what an "educated guess" might be of its value. One authority has stated a value, without supporting tests, indicating exciting current to equal full load current at 37 per cent excess voltage. For such an assumption our formula can be written

$$50 = (1.37)^X \text{ or } X = 12.43$$

or based on the foregoing design the increase would vary with the 12.43 power of the voltage ratio.

The discussion indicates quite definitely the need for operating the equipment as closely as practicable to the rated voltage limit. Doubtless many of your readers may be able to give information of kindred value from their experiences.

GRAPHITIZATION AND FAILURE OF STEEL IN SERVICE

NEARLY FIVE YEARS ago, the power plant industry was startled by a failure in a welded carbon molybdenum steel pipe which was part of a system operating at 1250 psi and slightly above 900° F. The fracture occurred circumferentially at the far edge of the heat-affected band adjoining the weld in the base metal and followed the contour of the deposited weld beads. The fracture line corresponded to that zone in the base metal which had been reheated to the lower critical temperature during the multiple bead welding.[1]

One of the best brief summaries of the discovery of the cause of this trouble and the subsequent steps taken to overcome it is given as follows in an issue of *Tempil Topics*.

Intensive investigation of hundreds of samples removed from service and fundamental research on graphitization in various laboratories under controlled conditions lead to the following conclusions. Plain carbon steels graphitize at lower temperatures than carbon molybdenum steels. Steels that showed marked graphitization in service were found to have been deoxidized with relatively large quantities of aluminum (about 1½ lb per ton or more) during the steel melting operation.

Graphitization is due to the slow decomposition of iron carbide in the steel structure under operating conditions. The carbon in these steels is normally combined chemically with iron in the ratio represented by the formula Fe_3C. The gradual decomposition of this compound at temperatures above 850° F results in the separation of the carbon as graphite. The latter may occur as fine or coarse nodules or in chain-like form. Chain graphite is especially dangerous because it lowers the strength and shock-resistance of the material.

The dramatic failure in the carbon molybdenum steel line was traced to chain graphite formation. No method of heat treatment is known which will dissolve the graphite or cause it to recombine with the iron to restore strength and ductility to the affected part. Therefore, when such a condition is discovered, the section or joint must be replaced.

The prevention of graphitization consists of adding sufficient chromium to the steel in steel-making to "tie-up" the carbon in a form less likely to decompose under service conditions. Today the user of high temperature piping has his choice of a number of steels containing ½ per cent to 2¼ per cent chromium together with molybdenum content of ½ per cent or 1 per cent for resistance to graphitization.

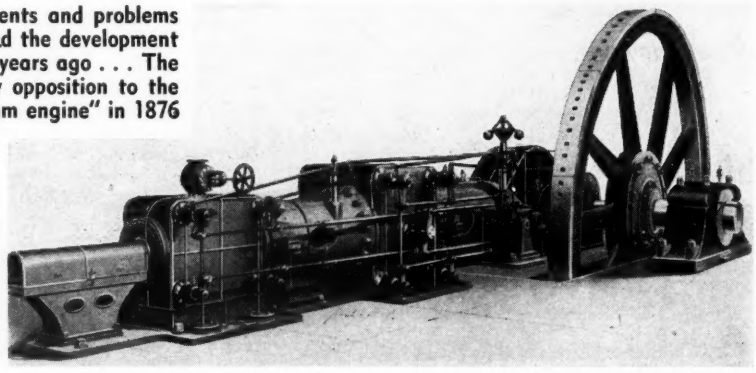
A recommended safeguard against eventual graphitization consists of proper preheating and stress relieving when welding these steels.[2] The higher the preheat temperature within practical limits (400 F to 650 F) and the wider the heat-affected band, the less the tendency toward graphitization. Even more important, the higher the stress relieving temperature below the critical range [1], and the longer the time of heating, the more effective the stress relieving treatment is. Modern practice prescribes heating between 1300 F and 1400 F for 4 hours, as adequate stress relieving to minimize the risk of subsequent slow graphitization.

[1]See TEMPIL® "Basic Guide to Ferrous Metallurgy" for definition and boundary of lower critical temperature.

[2]See paper on Influence of Heat Treatment Upon the Susceptibility to Graphitization of High Aluminum Deoxidized Carbon-Molybdenum Steel. F. Eberle. *Welding Journal*, v. 25, May, '46, p. 307s-312s.

"Why yes sir boss, this new machine practically runs itself—Great scott! What am I saying?"

Interesting sidelights about the incidents and problems encountered by the men that pioneered the development of power plant engineering some 150 years ago . . . The super power plant of 1835 . . . Early opposition to the use of steam power . . . "Largest steam engine" in 1876



Early heavy duty tandem Corliss engine built by Mesta Machine Company

Let's Salute the Old Timers!!

By CARL F. PALMER

WE, ENGINEERS OF TODAY, with our boiler codes, heat balances, steam tables, Reynold's numbers and slide rules think we have our problems in working out our designs and operating schedules. But just imagine with what the power engineer of fifty or a hundred years ago had to contend, and how much these engineers of the past century did accomplish in the improvement of power plant machinery.

Everyone knows the stories of the great names in power engineering, Watt, Bolton, Corliss, Parsons, Westinghouse, and the others, but, how about the run-of-mine engineers, nameless in history, who were responsible for the building and operation of these early plants? What were their problems, and how did they overcome them? History tells nothing of their tireless efforts and the thousands of problems which they had to solve without the benefit of our modern knowledge and technique.

Who decided how the early boilers should be built? These pioneers had no boiler code or previous experience upon which to base their judgment and very little data as compared to what we have today. They knew nothing about metallurgy or how various shaped vessels would react under temperature and pressure. True, some of the early boilers blew up, but many of them operated satisfactorily for many years.

The early engineer had to gamble more or less when deciding how many and what size his boilers should be to operate a given engine at full capacity. True enough, they knew the basic principles of thermodynamics, but practically nothing was available in the way of practical engineering knowledge. Yet, in spite of all this, they built power plants, hopelessly crude from our present day standards, which however, worked and accomplished their purpose.

In an old calf-skin bound volume, entitled "The Philosophy of Manufacturing, or An Exposition of the Scientific, Moral and Commercial Economy of the Factory System", written by Andrew Ure, M. D., F. R. S., and published in London, England, in 1835, we find a description of a factory power plant, then recently installed and running at Stockport. The author states that, after visiting many factories in England, this one was, by far, "on the most improved plan". We quote:—

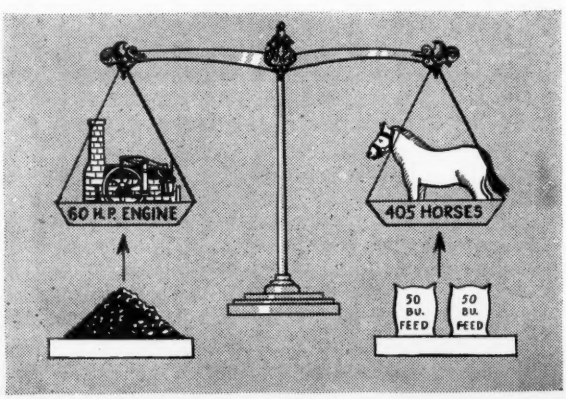
"The moving power consists of two eighty-horse steam engines working rectangularly together, which are mounted with their great gearing wheels on the ground floor, at the end of the body opposite the spectator's right hand, and are separated from the mill by a strong wall. This wall is pierced for the passage of the main horizontal shaft, which by means of great bevel wheels, turns the main upright shaft, supported at its lower end in an immense pile of masonry, of which the largest stone weighs nearly 5 tons. The velocity of the piston in each of the unison engines is two hundred and forty feet per minute; which, by the balance beam and main wheel, is made to give to the first horizontal shaft 44.3 revolutions, and to the main vertical shaft 58.84 revolutions per minute. As the one engine works with its maximum force when the other works with its minimum, the two together cause a uniformity of impulsive force to pervade every arm throughout the factory, devoid of those alternations so injurious to delicate and finely poised mechanism. The engines perform their task with chronometric ease and punctuality.

The boilers for supplying the steam to the engines, and to the warming-up pipes of the building are erected in an exterior building at the right hand end of the mill; and transmit the smoke of their furnaces through a subterraneous tunnel to the monumental-looking chimney on a picturesque knoll . . . . By means of this, a powerful draft is obtained, corresponding to the height of fully three hundred feet."

How many of our present power plant engineers would like to have the responsibility of building or operating such a plant!

Use of Steam Power Is Opposed

Perusing the same book further we learn that in 1835 there was consid-



An argument in defense of the early steam engine was that a 60 hp engine could operate for 24 hr. on 200 bu of coal worth about $23 in those days. 405 horses, the animal equivalent of a 60 hp engine, require approximately 100 bu of feed, worth about $110

erable opposition to the new "steam power" as is evidenced from the following argument presented in its favor:—

"The philosophy of Manufacturers is well displayed in the economy of power. The value of steam impelled labour may be inferred from the following statement of facts, communicated to me by an eminent engineer, graduated from the school of Bolton and Watt.

"A manufacturer in Manchester works a 60-horse Bolton and Watt's steam engine, at the power of 120 horses during the day, and 60 horses during the night; thus exhorting from it the impelling force three times greater than he contracted or paid for. One STEAM *horsepower is equivalent to 33,000 pounds avoirdupois raised one foot per minute; but one* ANIMAL *horsepower is equivalent to only 22,000 pounds raised one foot high per minute, or in other terms, to drag a canal boat 220 feet per minute with a force of 100 pound acting on a spring; therefore, a steam engine horsepower is equal in working efficiency to one live horse and half the labour of another. But, a horse can work at its full efficiency only eight hours out of the twenty-four, whereas a steam engine needs no period of repose; therefore, to make the animal power equal to physical power, a relay of 1½ fresh horses must be found three times in each twenty-four hours, which amounts to 4½ horses daily. Hence a common 60 horse engine does the work of 4½ times 60 horses, or 270 horses. But the 60-horse engine does one-half more work in twenty-four hours, or that of 405 living horses! The keep of a horse cannot be estimated at less than 1s 2d per day; and therefore that of 405 horses would be about £24 daily, or £7500 Sterling in a year of 313 days. As 80 pounds of coals, or one bushel, will produce steam equivalent to the power of one horse in a steam-engine during eight hours work, sixty bushels, worth about 30s at Manchester will maintain a 60-horse engine in fuel during eight effective hours, and 200 bushels, worth 100s, the above hard working engine during 24 hours. Hence, the expense per annum is £1565 Sterling, being a little more than one-fifth of that of the living horses."*

It will be noted that, based on the above, the expected fuel cost, alone, for steam power was in the neighborhood of 1.1c per horsepower hour, or $84.33 per horsepower year. The argument offered above, in defense of the steam-engine seems, in the light of present engineering, quite unnecessary, however, we, today, cannot realize the opposition which these early pioneering engineers met. The attitude of the people toward the steam engine can be illustrated by quoting from John Ruskin, the eminent art critic, who wrote the following, as late as 1868:

"It is always better for a man to work with his hands to feed and clothe himself, than to stand idle while a machine works for him; and if he cannot by all the labour healthily within him, feed and clothe himself, then it is better to use an inexpensive machine —as a windmill or waterwheel— than a costly one like a steam engine, so long as we have the natural force at our disposal . . . .

But the principle point of all to be kept in mind is that in every idle arm and shoulder throughout the country there is a certain quantity of force, equivalent to the force of so much fuel; and that it is mere insane waste to dig for coal for our force; while the vital is unused; and not only unused, but, in being so corrupting and polluting itself. We waste our coal and spoil our humanity at one and the same instant."

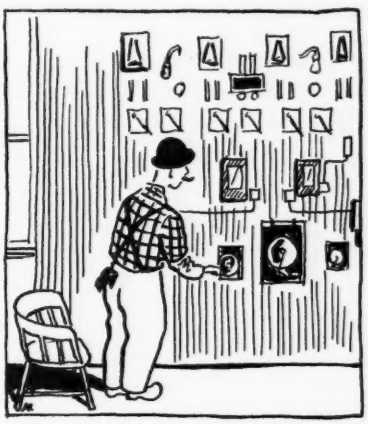
Going back to these early steam engines, it should be remembered that Bolton and Watt were the exponents of the low-pressure engine. Their engines seldom operated at higher throttle pressures than 7 psig. This pressure was governed largely by the open feed pipe of the boiler; the feedwater being supplied by a fixed head of water and not by a pump.

As late as 1872, according to Sir F. S. Bramwell, current marine practice called for boiler pressures from 40 to 65 psig and good economy was in the neighborhood of 2 to 2½ lb of coal per ihp-hr. Not until about 1881, with the advent of triple and quadruple expansion engines, were pressures increased to 150 and 200 psig; coal rates then dropped to about 1½ lb per ihp-hr.

The "Largest Engine Ever Built"

In connection with throttle pressures for steam engines there is a record of where, only about 70 years ago, low boiler pressure was instrumental in hindering the exhibition of a well designed and finely built steam engine. This occurred in 1876, when the Centennial of the birth of our nation was celebrated in Philadelphia by the American International Exhibition, better known as the Centennial Exposition. Over 9,000,000 people came to see this "World's Fair" and were thrilled by the many mechanical exhibits in Machinery Hall, prominent among these exhibits, and furnishing power for many of them, was the great "Centennial Engine", the product of the eminent engine builder, Mr. George H. Corliss, of Providence, R. I. This unit was advertised as the largest engine built, up to that time.

We are indebted to copies of the monthly publication, "The Manufacturer and Builder" for 1876 for the description of this engine and the story of its operation. The engine is described as a twin, walking-beam type, with cylinders 3 ft-4 in. in diameter and a 10 ft stroke. When operating at 36 rpm the piston speed was 720 fpm. The piston rods were wrought iron, 6¼ in. in diameter and were forged from 9600 horse-shoes. The cast-iron walking beams were 27 ft long and 9 ft wide, at the center. The two cranks were set 90 degrees apart with a cast-iron flywheel 30 ft in diameter and 2 ft thick at the rim and weighing 55 tons. This flywheel had 216 teeth cut in its face which meshed into a 10 ft diameter pinion, which in turn drove four lines of shafting totaling 1½ miles in length.



In the early days a switchboard was really a board with switches on it

The makers stated that this engine was "nominally" rated at 1400 hp, but was capable of producing 2500 hp. Applying the common engine formula we find that, with a mep of 40 psi, the rating would be 2192 ihp, so the manufacturer's claim does not seem unreasonable.

Steam for this engine was supplied through an 18 in. diameter pipe from 20 Corliss boilers in an adjacent building. There were many complaints from the other exhibitors that the engine could not supply the necessary power. In fact, it was estimated that it produced only about 400 ihp in actual operation. An investigation of these complaints showed that only ten of the twenty boliers were operated at one time, and these only between 9:00 a.m. and 2:00 p.m. It was also discovered that large quantities of steam were required for various pumping exhibitions and that this demand prevented the engine from obtaining its full supply. Several observers noted that the throttle pressure was from 8 to 13 psig!

Again applying the conventional engine formula, we find that for an output of 400 ihp, the corresponding mep is 7.3 psi. It therefore seems quite possible that the estimated output of 400 ihp was not far off. How-

ever, it seems remarkable that no attempt was made to supply this engine with the proper amount of steam, especially since there were a number of other boilers available in another building, including a 500 hp water tube unit.

This perhaps, is a suitable place to note the rules for proportioning boilers which were given this same year, 1876.

For Cornish type boilers, each horsepower should have:—

(a) 20 *cu ft of water space*
(b) 20 *cu ft of steam space*
(c) 60 *sq ft of heating surface*
(d) 2 *sq ft of grate area*

With this type of basic design data to work from, is it not remarkable that these early power plants were made to operate at all? Let's take our hats off to the power plant engineers of bye-gone days!

Silicone Insulations Reduce Motor Failures

Possibilities of Silicone Insulation . . . Effect of Silicone Insulation on motor life . . . Types of Silicone Insulations available . . . Application of Silicone Insulation . . . Cost of Silicone Insulation vs. Reliability

By F. S. CAMPBELL

THE RECENTLY developed silicone resins, that can successfully withstand elevated temperatures and moisture, and which possess good dielectric properties, hold out hope for overburdened motors in industrial plants. Motors insulated with silicone insulations have successfully passed very rigorous heat and moisture tests —tests that would have destroyed conventionally insulated motors in a fraction of the test time.

When compared with the best heat-resisting conventional motor insulation (glass cloth coated with a standard class B varnish), the greatly superior heat-resisting qualities of silicone-bonded insulating materials can be clearly seen. After 24 hr at 250 C, the silicone material retains its original flexibility. Class B material, however, after only two hours of the same treatment, is severely darkened and embrittled, having lost desirable electrical properties.

It is safe to say that the use of silicone insulation makes possible a class of electrical insulation serviceable at temperatures approximately 100 C above class B limits, and the proposed rating for this new class of insulation, including only inorganic materials bonded and impregnated with silicone resins and varnishes, is placed conservatively at 175 C (347 F). Tests show that silicone insulated motors will give a lot of service at 390 F and will withstand intermittent exposure to temperatures as high as 570 F.

Effects of Silicone Insulation on Motor Life

These facts, therefore, show that silicone insulation will greatly prolong the service life of electric motors operating under adverse service conditions; will provide greater freedom from overload failures; and will reduce fire hazards.

The moisture resistance of silicone insulation is also remarkably greater than that of class B insulation. Tests show that the insulation resistance of wet class B insulation drops considerably under 1000 megohms after being aged for 200 hr at 200 C, whereas wet silicone insulation has a resistance considerably above 1000 megohms after 600 hr aging. And while wet class B insulation possesses an insulation resistance of only 10 megohms after less than 300 hr at 200 C, silicone insulation tests higher than this after 1200 hr.

Some additional advantageous properties of silicone insulation include a heat endurance at 250 C of over 100 hr; a dry dielectric strength of 2500 to 3000 v per mil; a wet dielectric strength of 2000 to 2500 per mil; and a water absorption of less than 1/10 of one per cent after 24 hr and less than 15/100 of one per cent after 7 days.

Its chemical resistance is such that in tests it showed less than 1 per cent change in weight or volume after immersion for 7 days in dilute acids, concentrated hydrochloric acid, dilute and concentrated alkalies, mineral oil, and salt solutions.

But even such tests as this have not been the most severe to which silicone insulations have been subjected. During accelerated life testing, silicone insulated motors have been operated at 310 C (590 F) for a total of 5100 hr and have endured 41 eight-hour periods of humidification.

And these spectacular results have not been confined to a-c motors only. A d-c traction motor equipped with silicone insulation has withstood the equivalent of over 400 years' operation at normal temperatures.

Types of Silicone Insulation

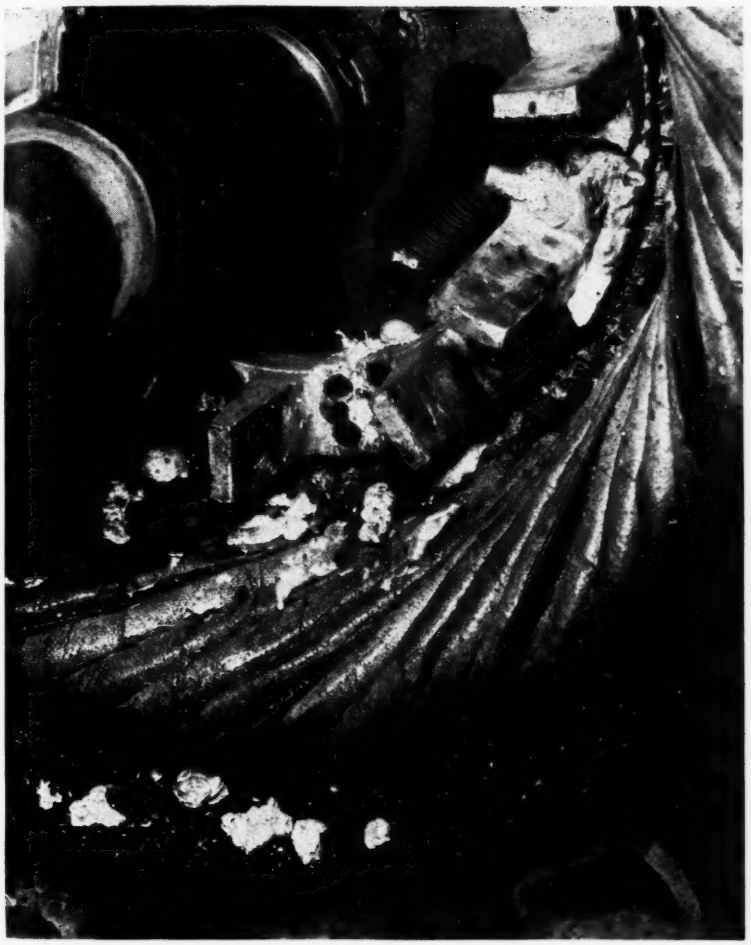
There are two types of silicone varnish now being produced by the Dow Corning Corp. One of these, known as DC 993, is used to bond and impregnate fibrous glass, asbestos and mica combinations in the production of silicone insulation components. It is also used for impregnating coils, motor stators, air cooled transformers and other electric machinery. It is applied in the same manner as conventional varnishes but requires a baking temperature of 450 to 500 F to cure.

Another silicone varnish, known as DC 996, now being produced in commercial quantities, has the same qualities as DC 993, but with the added advantage for motor service work that it cures at 300 F. Due to this lower curing temperature characteristic, most motor repair shops and motor repair departments of large plants can take advantage of the exceptional heat resistance and moisture proofness of silicone insulation when rewinding motor subject to severe service conditions.

Research work is still being done in the development of silicone magnet wire enamel for electrical insulating applications where space limitations will not permit the use of glass served wire. At present this enamel has many very desirable properties. At 250 C the flex life of wire insulated with silicone enamel is more than 30 times that of organic enameled wire. The water absorption of silicone enamel is low and its dielectric properties are very good. However, its physical properties are such that more careful handling of the coated wire is generally required.

Silicone treated fiberglass and mica-glass insulating materials, as well as DC 996 silicone varnish, are obtainable from a number of distributors. And when a motor is insulated with these materials and the assembly is properly impregnated with DC 996 silicone varnish, the job will have the best kind of insulation known to electrical engineers. It will withstand severe overloading for long periods of time. And even after long exposure to temperatures of 300 to 400 F it will still have high insulation resistance, wet as well as dry.

Silicone-resin insulations are available in various forms, among which are silicone-varnished glass cloth, used as backing for composite insulation, silicone-glass-mica wrapper, used for coil wrapping; silicone-glass-mica wrapper (thicker), used as phase insulation in stators; silicone-varnished glass-covered wire, employed in magnet and stator winding; silicone-bonded glass-mica tape, used as ground insulation for coils; silicone-sized glass tape, employed as a protective outer wrapping for coils; silicone-sized asbestos cloth, used as



Even after operating at temperatures hot enough to melt aluminum (melting point 1220 F.) Silicone insulation on this pump motor is in good usable condition. (Photo, Dow Corning Corp.)

a cushioning material; and silicone filling cement, which is a plastic filling cement.

Application of Silicone Insulation

In insulating a typical direct current motor, for example, the coils would be insulated with a silicone-bonded glass-mica tape, a glass and mica wrapper, covered with a silicone-sized glass tape, and finally impregnated with silicone varnish.

In the insulation of small induction motors, additional silicone materials are employed. The stator is wound with silicone-treated, glass-covered magnet wire. The coils are insulated from the core and between phases by mica and glass slot cells, silicone bonded. The stator is then impregnated and finally dipped in a high-temperature silicone varnish to furnish the waterproof external coating.

In applying DC 996 silicone varnish, conventional dipping, vacuum impregnating, or spraying methods are used. The varnish is furnished in a viscosity suitable for most uses. If, for any reason, it is desired thinner, V.M. and P. Naphtha is recommended for thinning.

The varnish in the tank should be kept at a viscosity of 1 to 2 poises for best results. This viscosity is equal to Demmler No. 1 Cup viscosity of 32-70 seconds or to a Ford No. 4 Cup viscosity of 32-60 seconds, both at 25 degrees C (77 F).

The recommended schedule for applying DC 996 is first to preheat the apparatus to be treated to remove all traces of moisture. Second, while it is still warm, dip until all bubbling stops, or vacuum impregnate. Third, remove from varnish and allow the apparatus to drain for at least 3 hr. Large equipment will take longer to drain. Fourth, bake at 70 to 90 C (160 to 195 F) until the solvent is removed. The time required will depend upon the size and construction of the apparatus being treated. Fifth, cool the equipment to room temperature and dip again, then remove from varnish and allow to drain as before. Six, bake again at 70 to 90 C (160 to 195 F) until the solvent is removed. If a thicker build up of varnish is desired, repeat steps five and six. Seventh, bake at 150 C (300 F) for 6 to 12 hr, depending upon the size and construction of the apparatus being treated.

Do not bake at 150 C (300 F) until the last dip coating has been precured at 70 to 90 C (160 to 195 F).

In cases where only a single dip is required, steps one, two, three, four and seven will complete the job.

In using DC 996, you do not have to worry about over curing because this varnish will not be harmed even by long periods of baking at 500 F.

Where motors are operating under overloads and other conditions that result in excessive maintenance, the use of silicone insulations will eliminate much of such annoyance and cost and will contribute greatly to the maintenance of production schedules. The somewhat greater cost of silicone insulating materials will be more than offset by the increased reliability and prolonged life of the motors treated with them.

DOG TAG

By SAM WILLIAMS

MANY INDIVIDUAL engineers, and perhaps more than one engineering society, are working in all sincerity, and to some purpose, in proposing legislation that would bring about the licensing of operating engineers. Their actions are based upon the grounds that such legislation would benefit the engineers, their employers, and society in general, by bringing about the condition that the engineers would have more knowledge of their profession, and in other ways be more valuable.

This writer is not in agreement with the above premises. He holds that legislation is not education, and that while legislation may in time force engineers to have more book knowledge, (of the kind required by the arbitrary demands of an examining board), that same legislation cannot force the engineer to use that knowledge, nor can he be driven to become efficient, intelligent, nor more interested in his work. Such characteristics are the products of inheritance, education and experience, prodded by economic necessity.

As an illustration of the rather illogical position of the proponents of this type of legislation, let us consider the current scene, and that it is proposed that if this bill became a law, engineers operating at present would be given a license without further ado. So, by waving of the legislative magic wand, the engineer, at one instant incompentent, becomes, at the next moment, most competent.

Let us not forget that the power to give is the power to take. That all manners of commodity have a way of being trafficked in. And that one more license is simply one more mile post on the road to a controlled economy.

The Case of the Middlin' Steam Trap

This Sherlock Holmes story brings out everything in the books about the maintenance of bucket steam traps . . . Besides getting a kick out of reading this tale, you will pick up a number of valuable practical tips

By GEORGE HOLMAN

MANY YEAR AGO Dumb Steamfitter 'come into repair shop where work Your Trulys, not exactly bright, either. He carry round steam trap foot high and eight inch across perimeter. "I took this trap offa the 200-lb line and put her on the 40-lb line just below the reducer, like you said," he tell Boss-man. "But she don't work any better there than she did above the reducer. I think she's dirty. Gimme a helper to clean her up." Boss-man say, "Let George do it." So, I are elect steam trap repair

man without port folio, or much else either.

Steamfitter set trap on bench. "She's gotta one-eight orifice," he say, and go off for smoke. Trap now my baby. All I know about steam trap make two-page book size of postage stamp filled with big letter O. I learn, I betcha. I try anything once. Even Hedy Lamarr.

Bust off two of six nuts holding cover plate on trap. Gasket stick tight enough to hold steam pressure without bolts. Use thin chisel and screw driver to pry cover plate off. Bust screw driver handle using it for wedge. Trap full of rusty sludge. Not clean since Heck was pup. Put bolts in can of gasoline. Take trap to steam lance and give her good blow. Goop splash everywhere, especially in left eye. Clean eye. Trap now clean inside. But broken gasket stick like bad reputation. Wear blister and get up sweat getting it off. Then look trap over to see why she don't kick bucket.

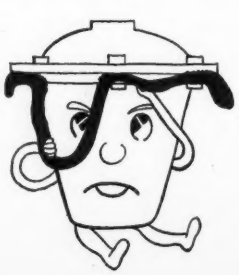
Bucket hang upside down from trap side like tin can from dog tail. Are puzzler here. Are bucket really upside down? Or, are trap downside up? Short bar connect bucket to trap wall. Bar have upright piece at middle with eye for stubby needle valve. When bucket lift, needle go into ⅛ in. eye hole out of trap, and stop it up. This keep trap shut off till bucket drop. Bucket have little round hole in bottom. Being upside down, this are also top. This hole look drilled, thereby puzzle me no end.

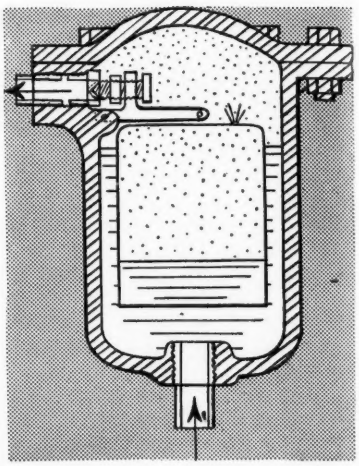
Figure out hole belong there. Get ready to put trap together. Make up mind if I are gonna hafta clean steam trap for bread and stuff, will take apart job easier next time. No more scraping off hard fiber gasket. Make one of soft rubber. Smear cup grease on both sides of gasket, thereby to make trap come apart easier next time. Nuts go on bolts hard, except new ones. Get tap and run through nuts. Get die and rechase bolt threads. Nuts go on spinning.

Tighten cover plate bolts. Grease on gasket squeeze out. Wipe off grease. Tighten nuts some more. More grease squeeze out. Rubber gasket get come out idea, and squeeze out, too. Trim it off with knife. Tighten nuts more. Rubber gasket go "Slup!" Between two bolts red rubber hang out like panting dog tongue.

Figure out grease cause gasket trouble. Take off cover. Throw ruined gasket under bench. Make new one. Wipe off grease. Put cover on, not so tight this time. Ho! Now, she go.

Take trap to pipe line where are 40-lb steam. Get right fittings. Connect her up. Open steam valve. Steam go right on through trap like shot through tin horn. Shut valve and open her easy-like. Steam blow out weak, stronger as I open valve more. Close valve and open her quick. Same old song. Sing it myself.

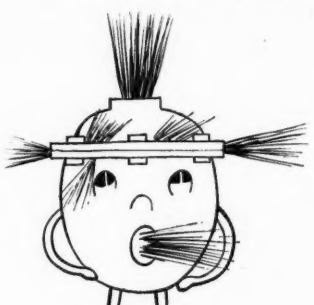




This inverted bucket trap was middlin'

Let little steam blow through trap while I try figure this one out. Are bucket up? Are bucket down? Or, are she middlin'? Smell rubber getting hot. Look see are I got rubber heel on cigarette butt. Make up mind bucket are middlin'. Good! Now, wide open valve blow her up, 'cause steam come in at bottom under her. Open valve wide. Water spurt out, then steam. Trap rattle like Model T on bumpy road. Pssssssst! Out come rubber gasket again, hot and sticky.

Take trap back to work bench and open it. Scrape off sticky rubber gasket. See why asbestos fiber gasket



right stuff for steam trap. Make up mind little hole in bottom cause bucket to middlin'. Get soldering iron and fill hole with 50-50.

On line again, trap still sputter and spit live steam. Old Timer come by. He say, "Ho! Kid. That kinda trap gotta be primed. See here." He connect up water hose, nearly close steam valve, and turn cold water on trap for five minute, maybe four. "Now, try her," he say.

Open steam valve wide. For five second stream of water shoot out of trap. Then water stop for two second. Pretty soon she can't make up mind whether spit out steam or water. So do both. "She balances on you, Son," Old Timer say. "She loses her prime. Maybe 'cause the seat leaks."

Take trap apart and grind valve into seat. Back together on line she rock and rumble, and let out steam with water. I look up Steamfitter and tell him everything I do, from goop to gasket. "So, you solder hole in bucket?" he ask. "Well, you gotta open it up. That hole gotta be there, or your trap get air bound. Air comes in with the steam and collects up inside the bucket. If that hole is closed, it won't let the bucket sink and open the valve."

Take Steamfitter advice. Melt off solder and drill out hole. Put trap together and prime with hose. After one water spurt, trap middle again.

Take trap apart. Look her over like she was new babe moved in next door. Piddle with this; piddle with that. Could be too much lost motion at needle valve. Put washer between eye in upright support and boss end of needle. No lost motion now. On line, trap middle more than ever. Take her apart and take washer out.

Old Timer say: "She won't hold per prime." Steamfitter say: "So, you drilled out hole? Maybe you got her too big." Boss-man say: "Bucket too heavy to let valve close."

Steamfitter shove me away and take trap apart himself. Boss-man watch and Old Timer help. They take heavy rim off bottom of bucket. Make lighter one of scrap iron and rivet it on. Then they try her out on line. All three grin from ear to appetite when trap spurt out water, then shut off dead. Are they please at display of mechanics know-how! In two or one minute I are snigker up sleeve as grins freeze to faces. Trap has started to fuss and spit like cat cornered by dog.

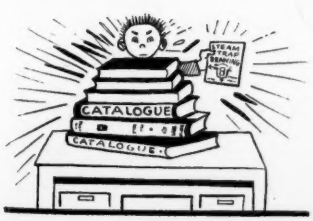
"You Gotta Get That Air Out"

Boss-man, Old Timer and Steamfitter go in huddle. "That's it." "Sure", I hear Boss-man say. "You've gotta git that air out, or she won't prime."

They take trap apart, fill her with water, then close her up. Water spurt for good ten second when steam valve are open. She close nice. But next time water spurt, trap are back fussing and spitting just like before.

Quitting whistle blow. I quit. But Boss-man, Steamfitter and Old Timer stay to work overtime on trap. After supper I work over time on trap, too. In mind. She are puzzler. I get out catalogues and study drawing of this trap. Make me some drawing myself. Copycat from catalogues.

Use imagination to figure out how



trap work. High power stuff, like time on bus I grab hand I see going into pocket. (Found out hand mine, but pocket wasn't). See trap inside like hookup on line, bucket down, valve needle open. See steam valve open. Steam come in at bottom. Some air got out port. Rest mix with steam and go out port together. Bucket stay down. Port stay open and steam blow out from now on. Why? No water to lift up bucket. Gotta have prime. Boy! Are I smart! Figure out that one, anyway.

Now water come in with steam. Stay in bottom of trap. Fill up to bucket rim. Some go into bucket. Push steam out through little hole. Bucket still down. Valve still open. Steam blow right out through little ⅛ in. hole, but not so fast as come in through ¾ in. pipe at bottom. Pressure in trap come right up to 40-lb line pressure. Water come up, too, but not so fast. Cover bucket and blow out through port. Bucket would float up if little hole didn't let steam out. Bucket would lift up anyway, if water would come in faster. Imagination won't let water come in faster. So bucket stay down. Valve stay open. Steam blow out, too. Why don't bucket go up? Bucket gotta go up if valve close.

Can't get bucket to go up in imagination. So back off, take new start, with bucket already up and trap as full of water as boarding house soup kettle. Except up under bucket. Steam there. But steam go out through little hole. Go through water and up to trap cover. As steam come out, bucket settle down and down. Now, bucket stop. But steam come right on out hole. Now, what wrong?

Sharpen imagination eye. Sharpen wits, which need it more. Why do bucket hesitate? Ho! Now, I see. Lost motion are gone at needle eye. Eye frame is back against needle shoulder. Valve still in seat. Steam pressure hold it there. Bucket only half full water when valve let go. Water above bucket blow out. Then steam go, too. Bucket only half full can't sink. Come right back up to shut off valve. Not enough steam in bucket to hold it up. Not enough steam pressure on valve to keep it from open till bucket fill. Bucket go up and down like cork when fish nibble. What will stop it? Lighter bucket? Ho! Maybe more pressure on valve do trick.

Still think on this when go to work next morning. Find trap on work bench. Boss-man, Steamfitter and Old Timer have look on face like dog caught sucking egg. Boss-man say: "We put a upright bucket trap on that line last night. If you get time today, George, look this one over again. There's some little thing wrong with it that we can't fathom. Maybe you can find it."

Take trap apart. Look her over good. Go back to last night thinking. Why do bucket hesitate when going down? Pressure hold her up at valve. Would be better if valve stay close till bucket full of water. Then valve stay open till bucket blow empty.

Get out pencil and figure. Pressure on size ⅛ in. hole are: ⅛ x ⅛ x 0.7854 x 40-lb are total 0.492-lb, or only ½ lb. Bucket weight maybe 4 or 5 lb. Not much help, that ½ lb. Now, if hole bigger, say ¼ in., total pressure be 4 times that much. Would make difference in middlin'.

Whet up wits some more. On pipe where this trap come from, pressure have 200-lb steam. Maybe so she don't work on that line 'cause of goop inside her. Pressure there holding valve to seat are 5 times on 40-lb line. 5 x 0.492 are near 2½ lb. Maybe bucket don't weigh so much.

Take new rim off bucket. Put old one back on. When others stop for lunch, take trap back where Steamfitter got it. Fill with water. Hook her up and open steam valve.

Nothing happen for five minute. Then spizzzzt! Water squirt a country block. Snap! Water stop. No steam. For ten minute nothing happen. Then spizzzzt! Away she go again. Snap. Off she shut. Nothing wrong with trap but place she in. Me, I figure her out. Upside down bucket trap gotta work at pressure made for, or have bucket weight or size of outlet hole change. I smart guy, I are. Or, are I?

IMPROVING PULLEY-BELT CONTACT

VERY OFTEN a pulley becomes very smooth on the surface due to constant slipping of the belt and causes a loss of speed and also heating which is transmitted to the bearing. Where the pulley carries a light load or runs at slow speed tightening of the belt may remedy the trouble, provided that the belt is not shortened to a point where it will wear out the bearing. There is an old rule to follow to make sure that the belt is not laced too tight; namely, to join the belt by hand removing all the slack and then take away ⅛ in. for every foot of belting. (This is readily done with a piece of cord. For example, if your cord or belt over both pulleys is 8 ft long, you remove one inch.)

For a number of years I have used a method that did not require a very tight belt. I cover the surface of the pulley with leather belting and secure it with several screws, counter sinking the belt so that the head of the screws are below the surface as in the illustration. In most cases this additional increase in diameter will not require lengthening of belt. Care should be taken on crown pulleys to draw the belt tighter at the ends than at the center, so as to follow the shape of the crown of the pulley.

New York, N. Y. MORRIS PODELL

Magnetic Separators for Power Plant Coal Handling

Nowadays, because of proper use of magnetic separating devices in power plant coal handling, we rarely feel the jolt that warns a roll tooth or hammermill slugger has been ripped off . . . Types of magnetic separators for various applications . . . Power consumption of separators . . . How to apply them . . . Special types for use under unusual conditions of application

By WILBUR G. HUDSON, *Consulting Engineer*

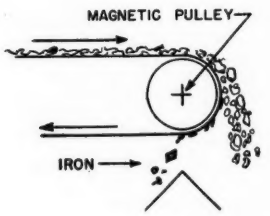
WHEN handling coal in the power plant, separation of undesirable foreign material is not always easy, especially because of the practice of plugging bad-order cars with rags, planks and chunks of clay. True, the hammermill and Bradford breaker will take care of such nuisances, and the difficulty lies more in lost time at the track hopper. Coupling pins, picks, bolts, pinch bars, etc., are easily culled out by magnetic separators and we now rarely get the jolt that says a roll tooth or hammermill slugger has been ripped off.

The usual device for culling out tramp iron is a magnetic head pulley on a belt conveyor as shown in Fig. 1. The power requirement for such pulleys is very small, as shown in the accompanying table.

A magnetic head assembly may be applied to an apron feeder by mounting the unit between the head sprockets. The head-end skirtboards should then be of non-magnetic material. The apron becomes magnetized as it approaches the head end and fragments of tramp iron adhere for several feet along the return run before they drop off. One difficulty is that, since the depth of load on the apron is a foot or more, the magnetic attraction may not suffice to pull the piece through the cascade at the discharge.

Sometimes a magnetized plate is suspended just above the material on a belt conveyor where it pours over the head as in Fig. 2. An objection to this plan is that, if the magnetizing current should fail momentarily, the fragments will drop back into the material.

In the great copper smelting plants, where it is essential to eliminate stray, but infrequent, iron fragments, one device suspends a balanced permanent magnet above the load on the apron con-



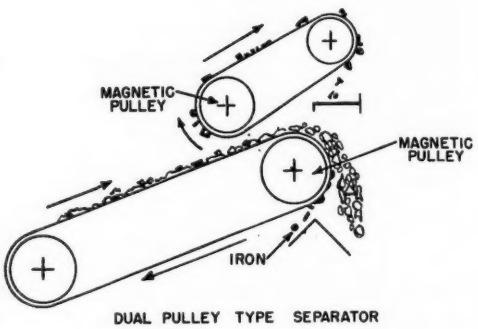
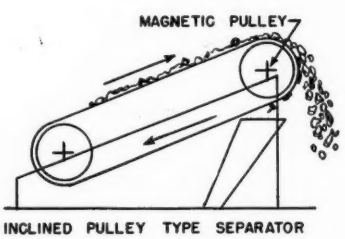
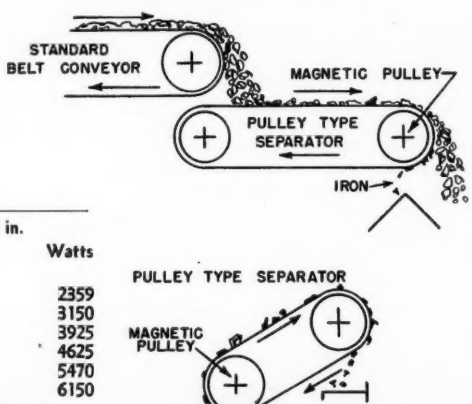


Fig. 1. Several typical arrangements of magnetic pulleys to suit class of material, conveyor layout and various service requirements



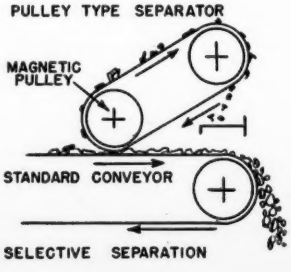


*The illustration shows the magnetic separator of Stearns Magnetic Mfg. Co. Other magnetic separating equipment is available from Dings Magnetic Separator Co., Cutler-Hammer, Inc., Electric Controller & Mfg. Co.

MAGNETIC HEAD PULLEYS*

Dia. 15 in.		Dia. 24 in.		Dia. 36 in.	
Belt width inches	Watts	Belt width inches	Watts	Belt width inches	Watts
14	625	18	1425	24	2359
16	675	24	1830	30	3150
18	690	30	2180	36	3925
20	715	36	2275	42	4625
24	1050	42	3000	48	5470
30	1375	48	3080	60	6150
Max. depth matl. 3 inches		Max. depth matl. 5 inches		Max. depth matl. 7 inches	
Max. belt speed, 160 fpm		Max. belt speed, 250 fpm		Max. belt speed, 350 fpm	

(Depth of material on belt and maximum belt speed as given are for the best results.) * Courtesy Stearns Magnetic Mfg. Co.



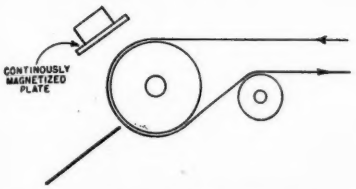


Fig. 2. Sketch showing how lift-off magnet may be used with a belt conveyor

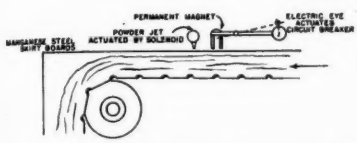

PERMANENT MAGNET
ELECTRIC EYE ACTUATED CIRCUIT BREAKER
POWDER JET ACTUATED BY SOLENOID
MANGANESE STEEL SKIRT BOARDS

Fig. 3. Magnetic separating or spotting device for use when iron is not frequent, as in copper ore feeder, with automatic stop by dip of permanent magnet

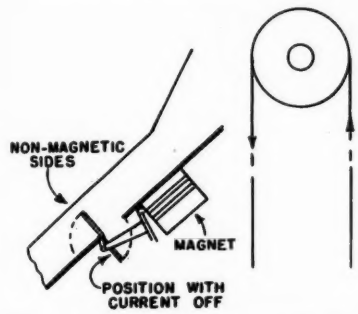


Fig. 4. How a chute-type magnetic separator can be installed

veyor as in Fig 3. A buried fragment dips the magnet sharply, actuating an emergency conveyor stop and causing a puff of talcum to squirt upon the load. A few trials suffice to establish how far beyond the powder-spot the iron should be looked for. Of course, this arrangement is suited ony to infrequent functioning.

Another device used where tramp iron is not too frequent is shown in Fig. 4. The magnet is mounted on the underside of the chute between an elevator and conveyor, and is interlocked with the elevator motor. Beyond the magnetized section of the chute is a pivoted flap actuated by the magnet. While the latter is energized, the flap forms part of the floor of the chute, but when the current is shut off, the flap pivots, and a few seconds later the iron fragments which have been trapped are freed and pass down the gap. If the fragment is heavy, impact may push it off and down the chute, though this is not easy.

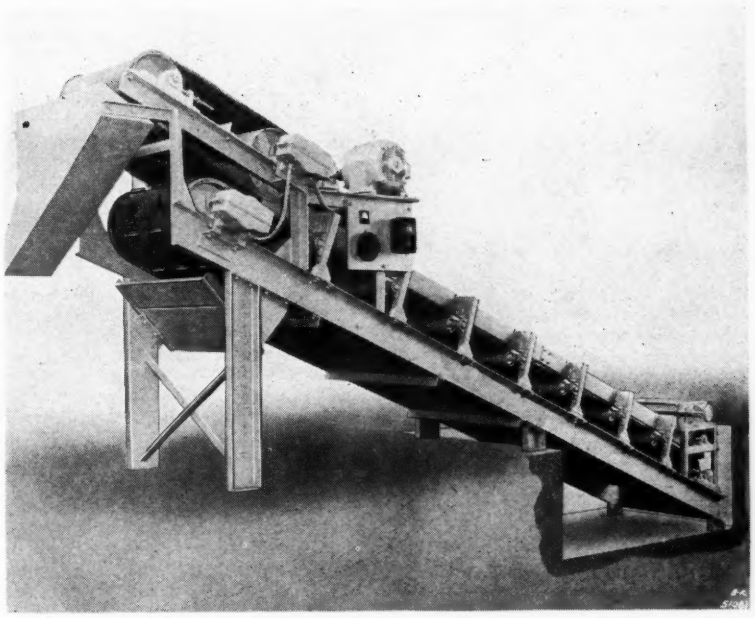


Fig. 5. Typical double-pulley magnetic separator unit

LETTERS AND COMMENTS

EVER HAVE BARNACLE TROUBLE?

THE FACTORY power plant, of which the writer is chief engineer went into operation during the spring rainy season of last year. The tidal river from which we take our condensing water supply was then completely fresh. Shortly after, a dry season, unusual during summer months, set in and the river became completely salt, (sea water).

We operated without any trouble until late in September when we noted an increased differential in head between the pump discharge and condenser inlet. Incidentally, the connecting pipe, which is thirty inches in diameter and five hundred feet in length, is laid horizontally underground from the pump house to the condenser basement.

Then came the fall rains and the river became fresh again. In a few days the condenser tube sheets began to foul up with barnacles, after only sixteen hours of operation, causing a high circulating water discharge temperature and loss of vacuum. This forced us to clean the condensers every night on the 12 to 8 shift.

This condition became intolerable when it got so we could not even run the necessary sixteen hours that the factory uses full power. We have three turbines; the stand-by turbine, fortunately, has a condenser with one inch tubes that did not plug up.

I decided to ask for a day's shut down and proceeded to drain out the water and turn live steam into the pipe for eight hours. I then flushed the pipe out with all condenser heads off, and all pumps running for four hours.

We collected more than a truck load of barnacle shell besides those that escaped in the flood. While the steam was on the whole vicinity smelt like a huge clam bake.

After starting up again, we still got empty shells on the tube sheets but, being empty, they allowed more water to pass. We were able to give sixteen hours' service to the factory, but had to scrape the tube sheets every night. This condition lasted a week, gradually diminishing.

Since then we have had no more trouble. However, I propose to devote a day every month in the dry season, when the river is salt, to draining the pipe and passing live steam into it to kill off the spores before they can form shells large enough to give trouble.

I estimated that the pipe was reduced in internal diameter by at least one-third as the barnacles stick, not only to the pipe walls, but to one another. They die and fall off when fresh water comes through, since they can only live in sea water.

I imagine the engineers that designed the plant never figured on this contingency, but I can tell the world it was pretty serious while it lasted!

Ciudad Trujillo,
Republica Dominicana

LUIS RENE DUVAL

WHY GREATER PRESSURE DROP WITH LIVE STEAM THAN WITH EXHAUST STEAM?

IN THE APRIL, 1946, issue of POWER PLANT ENGINEERING I desired an explanation of the reason for an excessive drop in steam pressure in a heating system under my charge. The question number was 328.

The difficulty seemed to be that when the heating system was supplied with live steam through a 2-in. reducing valve that with 3 lb pressure at the valve and feeding into a 10-in. pipe, a gage about 120 ft distant would read zero.

When using exhaust steam from an engine and with the same back pressure, the gage at the distant point showed about 2 lb pressure. Also the radiators at the farthest point of the system heated much better with the exhaust steam even when less than 3 lb showed on the gage in the power plant.

The above query started quite an interesting discussion which called attention to the theory that exhaust steam heats better than live steam on account of the belief that saturated steam gives off heat better than steam that would be superheated through a reducing of its pressure from 120 to 3 lb.

In your reply you felt that the 2-in. valve might not be large enough; another commentator laid the drop in pressure to the fact that the entire system would have a greater capacity to absorb the superheated steam than the saturated steam.

When using live steam for heating the vacuum pump had difficulty in maintaining 5 in. of vacuum which is the pressure that we try to carry on the return line. With the exhaust steam we could often carry 7 in. of vacuum.

Since the one fact that stood out above others in the discussion, seemed to indicate that the reducing valve was not large enough and also if a larger one were installed in its place it would be of no further use to the plant, it was decided to install a 1-in. valve to aid in supplying steam to the system. The capacity of this second valve is about 1100 pounds per hour.

We have set the weights of the 1-in. valve to close at about 3½ lb and we do the adjusting with the 2-in. valve but in case the pressure should happen to go too high the small valve would still close before the outside relief valve to the atmosphere opens.

The action of the heating system when using the two valves is somewhat surprising. For instance, when the system is being supplied by the 2-in. valve and maintaining 3 lb pressure, if the 1-in. valve is opened the larger valve immediately closes enough to keep the pressure at 3 lb and yet the radiators heat better and the vacuum jumps up to 5 and sometime 7 in. This must mean that increasing the capacity of the regulating valves we have so increased the ability to supply the system that we are approaching the section of the engine with it much larger port outlets into the heating system.

I present the above, thinking that it might be of interest to you and some of your readers.

Cambridge, Mass. G. H. KIMBALL

Questions And Answers

Question No. 407

HOW TO CALCULATE HEATING COIL FOR OIL STORAGE TANK?

WHAT IS the method of calculating the size of steam coils necessary to maintain No. 6 fuel oil at 140 to 160 F in various sizes of fuel oil storage tanks, both underground and above ground?

Sheboygan, Wisc. R. H. B.

Question No. 408

HOW SHOULD HE CLEAN OUT SOFTENERS AND RE-LAY BEDS?

I HAVE two 8 ft by 8 ft down-flow Zeolite softeners that will soon need to be emptied, scaled, and painted on the inside, and the beds re-laid. The units contain approximately 330 cu ft of standard green sand. The manhole is in the top head.

I would appreciate comments and suggestions from those who have had experience with this type of job, particularly on the best method of removal and as to the best paint to use for protection against corrosion.

Junction City, Kan. C. J. R.

Answer No. 393

HOW ARE COPPER OXIDE RECTIFIERS MADE?

IN THE AUGUST issue, H. L. asked how copper oxide rectifiers are made; that is, what materials are used, what is the actual physical construction? There has been much discussion in AIEE papers and elsewhere, he said, of the theory and application of these rectifiers but little on their manufacture.

Returning to the copper oxide rectifier, it certainly is true, as H. L. says, that there is a dearth of information on their manufacture, but we have finally found some information, which is given below.

As to their theory, a number of papers on the subject presented before the AIEE are incorporated in the *Transactions* of the Institute. Others have appeared in the *General Electric Review* and, if we remember correctly the old *Electric Journal*, formerly published by Westinghouse but now discontinued, had a number of articles on these rectifiers. The Union Switch and Signal Co. used to make them.

One of the first papers ever published on the subject was entitled "A New Electron Rectifier" by L. O. Grondahl and P. H. Geiger, in the February, 1927, AIEE *Transactions*.

Another good discussion of the fundamental characteristics and applications of these rectifiers was entitled "Fundamental Characteristics and Applications of Copper-oxide Rectifiers" by C. E. Hamann and E. A. Harty, in the August, 1933, issue, *General Electric Review*. This paper is one of the few that has a few paragraphs dealing with construction, as follows:

Construction of Copper Oxide Rectifiers

Early in 1920, while studying the photoelectric properties of cuprous oxide, it was discovered that under certain conditions the resistance of this material was greater in one direction than in the other. Further investigation revealed that it was possible to obtain a high ratio of resistance between the forward and reverse directions, resulting ultimately in the development of the copper-oxide rectifier.

The fundamental part of the rectifier consists essentially of a copper disk or washer, which has been heated in a furnace to a high temperature and subsequently quenched in water. This treatment produces a thin film of cuprous oxide with an outer layer of cupric oxide. The latter is then removed, leaving the copper disk with a layer of cuprous (red) oxide on one side.

The junction between the mother copper and the red oxide has the valuable property of permitting electrons to flow more readily from copper to oxide than in the reverse direction; that is, the junction offers a high resistance to the flow of current from copper to oxide and a relatively low resistance in the direction of oxide to copper, thus constituting a one-way electrical valve.

Contact with the oxide surface is usually made by means of a lead disk held under pressure. By assembling on an insulated bolt, in proper

sequence, a number of these pairs of treated copper disks and lead disks, each pair being designated an "element," it is possible to rectify alternating current and obtain a wide range of direct-current output.

Answer No. 399

115-V EXTENSION LIGHTS ARE DANGEROUS INSIDE BOILER DRUMS

FOR MANY years we had used extension lights of the 110-v type in our regular boiler inspections. This, of course, is safe provided the boiler drums or other metal surfaces are dry. However, one of our operators, while working inside of the fire box on a chain grate stoker shortly after a cleaning, had himself grounded to the grates due to water on the grates, wet shoes and perspiring hands. Fortunately, it was not a serious accident, for one of the men who was helping him yanked the cord from the receptacle.

Serious accidents can happen when using 110-v extension cords around wet metal surfaces and the National Safety Council has sent out warnings to that effect.

R.H.N. can use the ordinary 115-v circuit and install a transformer between the outlet and the lamp. Some of the operators I know use a 6-v light taken off a transformer from a 115-v receptacle. If R.H.N. is interested in a low-voltage extension cord, I will gladly send him the address of a manufacturer who makes these cords and transformers for this type of work.

Your engineers must remember one thing: that is, 115 v can kill if grounded to wet surfaces, whether boilers or other metal surfaces. In my judgment, it will be better to be safe than sorry. No one can tell how a workman can get electrocuted using 115-v lights.

I would explain to his superiors the danger involved and show them that for a few dollars a risk can be eliminated; unless, of course, his superiors have no regard for safety; then R.H.N. will have a tough nut to crack.

In our plant, our management has safety uppermost in their minds and if any man brings to management's attention an unsafe practice and ways and means of eliminating these hazards, he is rewarded by a small bonus.

JOHN F. SLAVINSKY

Rochelle Park, N. J.

Answer No. 403

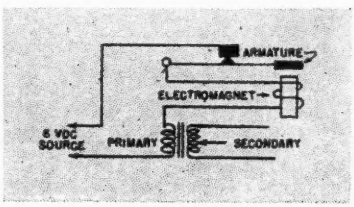
HE WANTS A LOW-VOLTAGE TRANSFORMER

IN THE QUESTION, concerning low voltage transformer, Mr. Stith states that a string of sparks jumped about ⅜ in. between the outside leads on the secondary.

If my memory is correct, a potential of 25,000 v or more is necessary to cause a flashover between adjacent terminals, when separated a distance of 1 in. and with a relatively low humidity atmosphere as the dielectric. Since the string of sparks jumped a distance equal to ⅜ in., I believe that Mr. Stith's transformer has a surge voltage in the secondary of 12,000 v or more.

What may have been overlooked by Mr. Stith, was the possibility of high surge voltage existing in the transformer secondary, from the inductive kick of the ordinary type of buzzer, when the field winding circuit of the electromagnet, is interrupted and closed, many times per second.

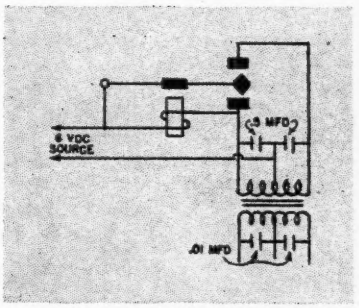
Since a detailed description of the type of buzzer used is not given, I am assuming that it is the more common and cheaper type in which the armature or reed motion is caused by the alternate closing and opening of the electromagnet field winding circuit as described above, rather than the system used in the better types, that of alternately short circuiting the electromagnet field winding to cause the magnetizing and demagnetizing of the core.



I am also assuming that Mr. Stith did not use a relay, but hooked the buzzer in series with a 6 v source and the trans. primary as shown in Fig. 1 "Hooked up", in this manner, the current is interrupted, not only through the primary of the transformer, but through the electromagnet field winding as well. Since electromagnets are generally wound with many turns of fine magnet wire, it is reasonable to assume that the alternate building up and collapsing of this magnetic field across them, will cause a high induced emf which, in turn, is impressed across the transformer primary where it is further increased in potential by the ratio of 6400 to 90 or about 70 to 1.

If the surge voltage generated in this matter were only 200 volts in the primary circuit, the 70 to 1 ratio would raise it to about 14,000 v in the secondary, enough to cause "flashing over" on the ⅜ in. leads.

A commercial type of non-synchronous vibrator and the necessary transformer can be purchased so cheaply, that I believe it would pay Mr. Stith to buy one of these, rather than experiment with a home made unit. Any radio service man can order one for him, as they are used in auto-radio power-packs. The term, non-synchronous, is used to distinguish it from the synchronous type, which not only performs the function of a vibrating



switch on the transformer primary circuit, but at the same time acts as a mechanical rectifier on the secondary circuits. However, we are not concerned with the synchronous type, so no further description is necessary.

The transformer used in these sets is specifically designed for this type of work, and differs from that of Mr. Stith's, principally in the design of the primary winding, which is center tapped.

As shown in Fig. 2, the primary is connected to the vibrator contacts in such a manner that a movement of the reed in one direction allows current to flow through one-half of the winding, and the movement in the reverse direction allows current to flow through the other half of the winding in the opposite direction. Here the vibrator acts as a reversing switch, rather than as an interrupter, and since the direction of current flow in the primary is actually reversing, it is truly an alternating current, rather than a pulsating d-c. However, it is not sine wave in character.

Also, when the armature and its associated reed is attracted to the core of the energized electromagnet, the reed and its contacts short circuit the winding of the electromagnet weakening its field and allowing the reed to spring back, due to its own resiliency, where the same cycle is repeated, usually at the rate of 60 to 120 times per second. During the short circuit period, normal current flows through that half of the primary connected in series with the magnet winding, since at that instant the magnet winding is effectively shunted.

Any surge voltage induced in the magnet winding is dissipated in the short circuit that is across its windings, thus eliminating the high voltage effect in the secondary, which I think Mr. Stith is experiencing, and also considerably reducing the sparking at the vibrator contacts.

The sparking at the contacts is further reduced by using capacitors, resistors, or combinations of both across the primary and secondary of the transformer. This also improves the wave form and the effect can be readily checked with an oscilliscope. Approximate capacitor valves are used in Fig. 2, as they will vary with different transformer and vibrator characteristics.

St. Louis, Mo. JESSE L. ERISMAN

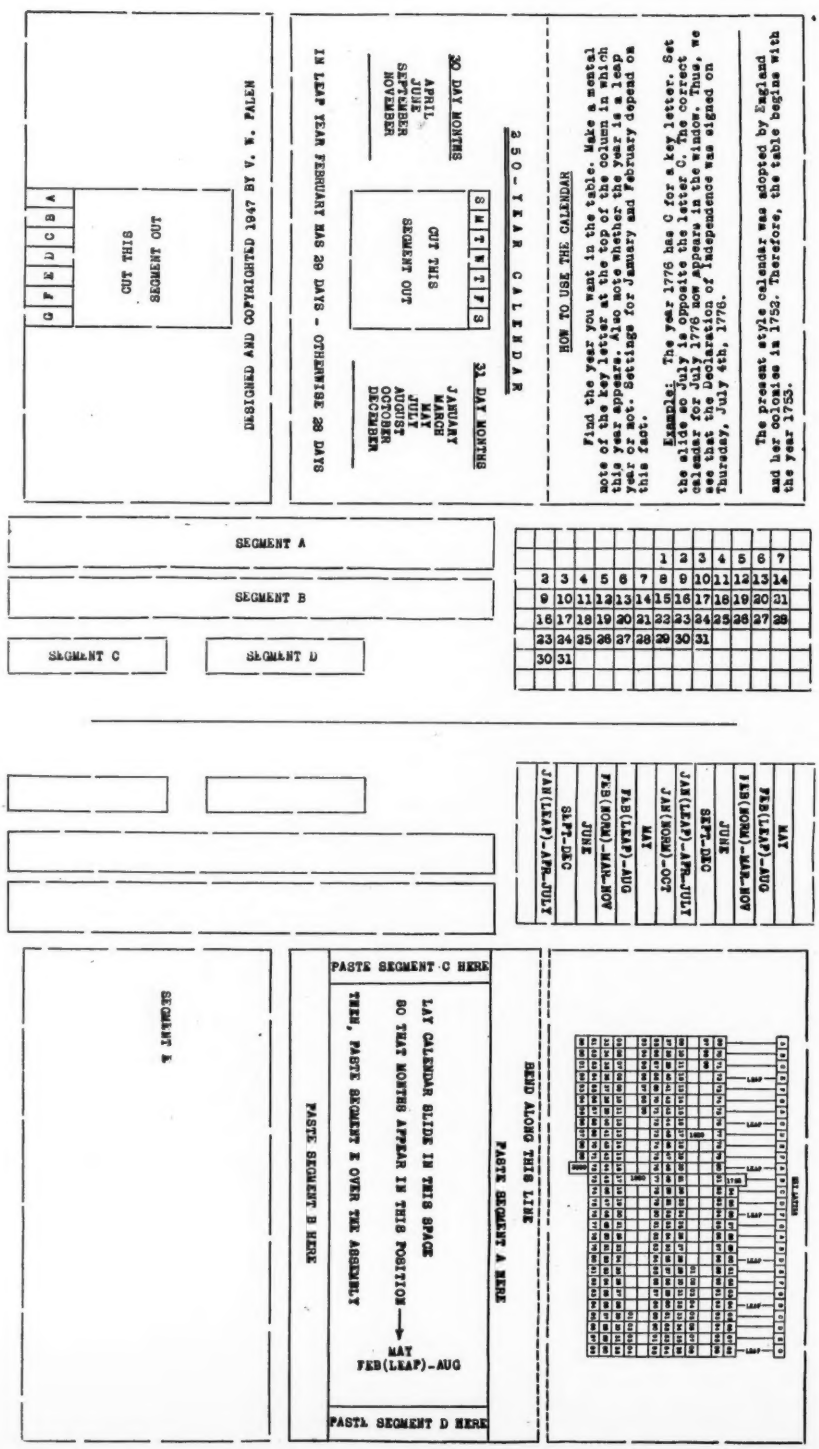
250 YEAR CALENDAR

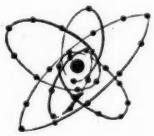
Have you ever wondered on what day of the week you were born, or on what day the Declaration of Independence was signed? You need not be curious any longer because you can now find out with the 250-Year Calendar shown at the right. This calendar enables you to select the current month, or any other month for the years 1753 to 2000. Incidentally, the present style calendar was adopted by England and her colonies in 1752; therefore the table begins with the year 1753.

It is often important to know, for example, how many Saturdays there were in a month say, 5 years ago. Such information is valuble when making comparisons of business volumes and sales.

To assemble the calendar, first cut out the two sides and paste them, back to back, on a piece of cardboard, making sure that either side is properly aligned with the other. Next take a razor blade or knife and cut out the various segments as shown. Paste these in position, and your calendar is ready to use.

Instructions are simple; pick out the year you want in the table and make a mental note of the key letter at the top of the column in which this year appears. Also note whether or not this year is a leap year as settings for January and February are dependent upon this fact. Move the slide until the month you are interested in lines up with the key letter. The calendar appears on the reverse side. (Copyrighted 1947 by V. W. Palen)


G F E D C B A
CUT THIS
SEGMENT OUT
DESIGNED AND COPYRIGHTED 1947 BY V. W. PALEN
IN LEAP YEAR FEBRUARY HAS 29 DAYS - OTHERWISE 28 DAYS
30 DAY MONTHS
APRIL
JUNE
SEPTEMBER
NOVEMBER
CUT THIS
SEGMENT OUT
S M T W T F S
31 DAY MONTHS
JANUARY
MARCH
MAY
JULY
AUGUST
OCTOBER
DECEMBER
250 - YEAR CALENDAR
HOW TO USE THE CALENDAR
Find the year you want in the table. Make a mental note of the key letter at the top of the column in which this year appears. Also note whether the year is a leap year or not. Settings for January and February depend on this fact.
Example: The year 1776 has G for a key letter. Set the slide so July is opposite the letter G. The correct calendar for July 1776 now appears in the window. Thus, we see that the Declaration of Independence was signed on Thursday, July 4th, 1776.
The present style calendar was adopted by England and her colonies in 1752. Therefore, the table begins with the year 1753.
SEGMENT A
SEGMENT B
SEGMENT C
SEGMENT D
SEGMENT E
PASTE SEGMENT C HERE
LAY CALENDAR SLIDE IN THIS SPACE
SO THAT MONTHS APPEAR IN THIS POSITION
MAY
FEB(LEAP)-AUG
THEN, PASTE SEGMENT E OVER THE ASSEMBLY
PASTE SEGMENT B HERE
PASTE SEGMENT D HERE
BEND ALONG THIS LINE
PASTE SEGMENT A HERE
JAN(LEAP)-APR-JULY
SEPT-DEC
JUNE
FEB(NOM)-MAR-NOV
FEB(LEAP)-AUG
MAY
JAN(NOM)-OCT
JAN(LEAP)-APR-JULY
SEPT-DEC
JUNE
FEB(NOM)-MAR-NOV
FEB(LEAP)-AUG
MAY



ATOMICS

A New Section added to POWER GENERATION to cover current and forthcoming developments in atomic energy and related developments and applications in Nuclear Physics

Heat Transfer and Nuclear Energy

Nuclear energy is essentially heat energy. It is kinetic energy—the kinetic energy of fragments of exploded nuclei. Nuclear fission, itself, is represented by temperatures of thousands of millions of degrees. This temperature has to be transferred, stepped down, to values that can be used in heat engines before we can hope to utilize this energy for the benefit of man. Its use, therefore, depends upon heat transfer; upon the development of effective methods and equipment whereby the energy can be transferred to thermodynamic systems involving heat engines

By **ANDREW W. KRAMER**, *Editor, Power Generation*

THE PHYSICS of the atomic bomb may seem far removed from the practical work of the power engineer and so it is, if it was confined to the bomb alone. The physics of the bomb, however, constitutes only a small part of the much more comprehensive field of nuclear physics, that is, the field of investigation of nuclear energy for all purposes. True, at present, no nuclear power plants are in existence but that does not mean that power engineers can ignore the question of nuclear power. Nuclear power is coming just as surely as radio followed the discovery of electromagnetic waves; indeed, the pattern for the nuclear power plant is set; there are no fundamental mysteries involved in its design. It will be a *heat* operated plant; heat derived from the fission of atomic nuclei will be transferred to gas or liquid for the operation of steam or gas turbines.

The idea itself is simple—almost as simple as the ideas underlying the design and operation of present-day steam electric generating plants. There will be a nuclear furnace in which heat is generated and there will be heat exchangers operating in conjunction with turbogenerators. There are, however, a great many "engineering" problems to be solved, many of which involve the question of heat transfer.

When a nucleus of uranium-235 splits, the fragments fly apart at a velocity which, expressed in terms of temperature, is measured in *thousands of millions* of degrees. This *unorganized* kinetic energy has to be organized before it can be made to do work in a turbine or other type of heat engine. In other words, the heat developed as a result of nuclear fission will have to be transferred to a liquid or gas which can be delivered to a prime mover. This transfer of heat is not simple—not nearly as simple as that in a conventional fuel-fired boiler furnace. As in the fuel-fired furnace it is a complex combination of conductive, convective and radiative heat transfers, but made much more difficult by the presence of extremely dangerous radioactive radiation and a speed of reaction that is practically instantaneous.

Thus, the first vital problem that will have to be solved before nuclear reactors can be used for producing power is the heat transfer problem. Those most concerned with the development of atomic energy for power realize this. Early in December, a heat transfer symposium was held at Oak Ridge, Tennessee, which was attended by the nation's most noted authorities on heat transfer. For a solid week these men lived, dreamed and talked heat transfer; they discussed it from every angle, turned it inside out. There were efforts toward simplification of theories, pleas for new approaches and the adoption of new, modern nomenclature.

Atomic energy? It was scarcely mentioned. Somehow it seemed unnecessary; one instinctively understood that these matters of heat transfer would have to be cleared up before a start could be made on the atomic problem.

Much of what was discussed at Oak Ridge was in the realm of fundamental theory; it involved a great deal of mathematical analysis and not a little difference of opinion. Strangely enough, the question of heat transfer is far more complex than the phenomenon of nuclear fission. The fundamental principles of nuclear fission can be explained to any ordinary person of intelligence but no one who has not spent a great deal of time and study on heat transfer could hope to understand modern theories of heat transfer.

Why should this be so? Heat transfer deals with simple things—things we can see, feel, hold in our hands;

that is, it involves tubes and vessels made of steel, copper, nickel, etc., liquids and gases, insulating and conducting materials. Nuclear fission on the other hand is a mysterious process, dealing with entities far beyond our powers of vision and whose existence until recently was never even suspected. The neutron was unknown until 1932.

The reason for this difference of course is due to the fact that heat transfer involves a great variety of materials in different states, all of which vary with time, temperature, structure, movement dimension, etc. In other words, heat transfer involves a great many dependent and independent variables. In determining the heat transfer characteristics of an ordinary tubular heat exchanger, the designing engineer must consider such factors as, tube diameter, thickness; tube length; roughness of pipe surface; velocity of liquids or gases involved; acceleration due to gravity; mass, force; density of liquids or gases at varying pressures and temperatures; specific heats, pressures; viscosities; conduction constants. These are only a few. In addition the heat transfer engineer has introduced a number of dimensionless factors such as Reynolds number, Nusselt number, Graetz number, etc., all of which complicate the procedure of calculating heat transfer characteristics. Many assumptions have to be made and much of the heat transfer engineer's work in the past has been in running tests on heat transfer equipment to see how closely practical performance confirmed his theories and methods.

These aspects of heat transfer are unavoidable. The transfer of kinetic energy of heat from one medium to another through the agency of solids, liquids and gases in differently shaped vessels under varying conditions of temperature, pressure, density, viscosity, etc., will always be a complex problem and one which will never yield to 100 per cent accuracy.

The problem of heat transfer has been sufficiently difficult in the design of conventional boiler equipment but it is going to be even more difficult to solve it in the case of the nuclear reactor heat exchanger.

The nuclear reactors that have been in use so far in the production of plutonium have been operated at low temperature—temperatures at which the carbon moderator remains stable and structurally intact. What the carbon moderator would do at a temperature of 1500-2000 F under the conditions existing in a pile is something that will have to be determined.

As is well known, the nuclear reactors now in use, consist of a large

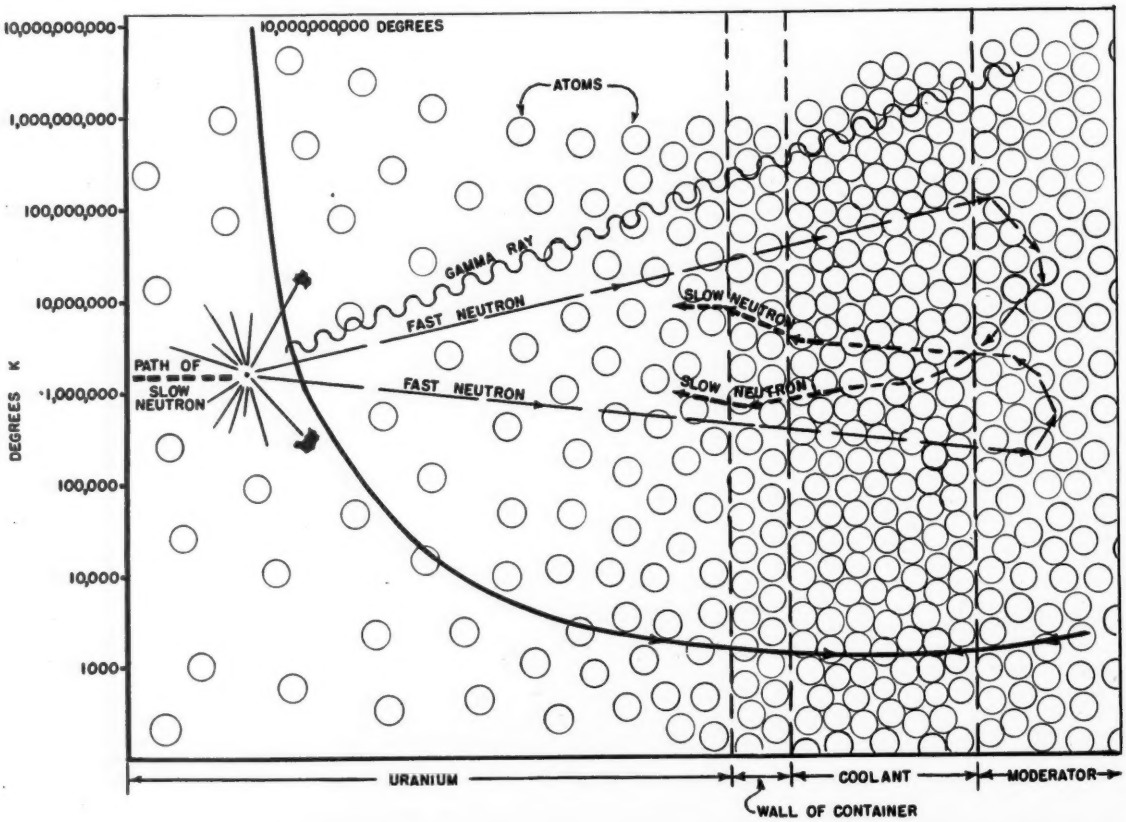


Fig. 1. This diagram attempts to show the heat or energy transfer in the fission of uranium in a nuclear reactor from the uranium to the cooling medium. In this diagram the vertical axis represents the scale of temperature in degrees Kelvin. The horizontal axis represents the distance from a point in a uranium rod to a point in the moderator material. The uranium is separated from the coolant by means of a metal envelope. In this particular illustration, it is assumed that the coolant will be heated to a temperature of approximately 1000 degrees, as would be necessary in the operation of a nuclear power plant. The circles represent atoms and the distance between them is a rough measure of their thermal velocity. Close to the point where fission occurs in an atom of uranium, the thermal velocity is, of course, very high. Since the kinetic energy of the fission fragments is given up to millions of surrounding atoms, the temperature gradient (Kinetic energy gradient) is very steep at first. As more and more atoms become involved, the slope of the curve decreases. From an initial temperature of 10,000 million degrees it levels off to around 1000 degrees. The fission fragments, being very large, do not travel far; they give up their energy to the uranium atoms. The neutrons produced by the fission, being small and carrying no electrical charge easily pass through the uranium atoms as well as the walls of the envelope containing the uranium, and the coolant until they reach the moderator. There they are slowed down and drift back into the uranium as slow neutrons. In their passage through the moderator they heat the latter as does also the gamma radiation absorbed by the moderator. Hence, the moderator also loses heat to the coolant

mass of carbon containing cylindrical holes in which rods of uranium-235 are placed. The uranium is contained in aluminum cans so designed as to leave an annular space between the outside of the aluminum tube and the inside walls of the cylindrical passages. Thus, a coolant can circulate between the cans and the walls of the passage.

The design of the nuclear power plant involves not only the structure of the pile itself but also the selection of the coolant or heat absorbing medium. A number of requirements must be met in the selection of the coolant. First, it must resist the intense neutron bombardment in the pile without having an appreciable fraction of its mass converted into some other element. As pointed out by C. P. Cabell in a recent article[1] strange things happen in a pile. Nitrogen, a gas, comes out as carbon; silicon comes out phosphorous; gold comes out mercury; and sodium comes out magnesium. The pile can even make gold but it takes platinum on which to perform this miracle!

Another factor of great importance is that the material selected as the heat transfer medium shall not be unduly corrosive and should remain a liquid at high temperatures and under relatively low pressures. During its passage through the pile, the heat transfer medium will become intensely radioctive and by specifying low pressure at high temperatures the designer will reduce the operating difficulties experienced in handling a highly radioactive material at high pressures.

The medium must not absorb an excessive amount of neutrons since neutrons are the life-blood of the pile operation. Since all materials absorb some neutrons it is necessary that only a small amount of coolant be contained in the pile at any time. At the high heat loads which will prevail, this requirement will entail extremely high rates of heat transfer and great care in the design of the cooling passages.

There are innumerable other problems. Because of the intense radioactivity the entire heat transfer system will have to be enclosed in heavy shielding. And there can be no leaks into the vapor side of the system. If steam were used a leak would contaminate the steam and this would not only constitute a source of danger to personnel but the introduction of steam or other vapor into the pile would disturb the delicate balance under which the nuclear reactor operates. The control must never get out of hand.

Compared to a fuel-fired furnace the reaction speed of the nuclear reactor is extremely high. When the combustion process in a conventional furnace increases the temperature

[1] Nuclear Power. *General Electric Review*. December, 1947; p. 11.

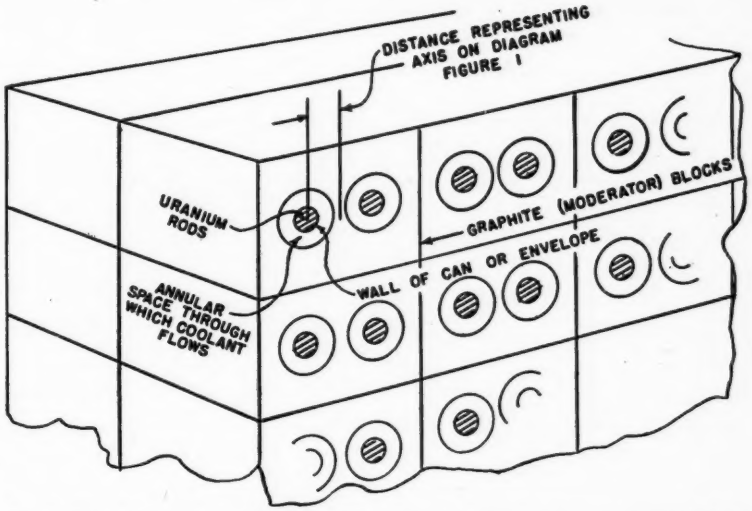

DISTANCE REPRESENTING AXIS ON DIAGRAM FIGURE 1
URANIUM RODS
GRAPHITE (MODERATOR) BLOCKS
WALL OF CAN OR ENVELOPE
ANNULAR SPACE THROUGH WHICH COOLANT FLOWS

Fig. 2. This diagram of a corner of a nuclear reactor shows the distance represented by the horizontal axis on Fig. 1

rises and the steam pressure goes up. This causes the combustion control equipment to function, to reduce the draft, diminish the fuel supply, etc., until the combustion process decreases to normal value. Even without automatic combustion control, there is usually ample time for an operator to make the necessary draft and fuel adjustments manually.

In the case of the nuclear reactor an entirely different situation prevails. The operation of a nuclear reactor depends upon what is known as the k factor. The k factor is the number of those neutrons produced in each fission which are available for the next fission. Thus, a value of 1.00 for k means that each fission produces exactly enough available neutrons to cause another fission, and that a fixed quantity of neutrons is being formed and destroyed each instant. Thus, as long as k has a value of 1.00 the power output of the reactor will remain at a constant level.

Actually, of course, a pile is designed with a k factor greater than 1.00. For operation at a given power level, k is brought down to 1.00 by the use of neutron absorbing rods which are moved in and out of the pile. If the k factor tends to increase, the rods are moved into the pile, if it tends to decrease they are pulled out. To start the operation or to raise the power level, the rods are moved to a point where k is slightly more than 1.00. Then the number of neutrons produced per second will increase exponentially, the speed of the increase depending upon the amount by which k exceeds 1.00.

In principle, this system of control is similar to a furnace combustion control system but in action it is quite different. Note, that the number of neutrons produced increase *exponentially*. This means that the rate of increase in the number of neutrons is proportional at every instant to the total number in existence at that instant and this means that the rate of increase is extremely fast.

Suppose a uranium pile was designed with a k factor of 1.01. This would mean that for every 100 neutrons consumed, 101 were produced. This increase is small but atomic reactions are the fastest things in the universe; the fission fragments fly away at speeds of hundreds of millions of miles per hour. And, these fragments have only to move interatomic distances before they encounter other atoms. Suppose the new neutrons are released instantly after fission. They also will be traveling at speeds of millions of miles per hour and will have to travel only a few centimeters through the moderator before they are slowed down to a speed where they can produce fission in an adjacent lump or rod of uranium. A single cycle of this kind takes place in an interval of time so infinitesimal as to be capable of measurement only in billionths of a second. If all the new neutrons were emitted instantly at the time of fission, billions of cycles would be completed in a single second. If each cycle were only 1 per cent more violent than the last, the reaction would increase in violence *one billion per cent per second*. In two seconds it would be one million million million times as violent.

In the absence of delayed neutrons, a pile can increase its power by a factor of e, that is 2.718, in an extremely short time. If for example a pile designed to operate at 25,000 kw should get out of control with an excess multiplication content of 0.10, it will be at a level of 67,500 kw in 0.01 second.

One need not carry this on further to make clear what would happen within a tiny fraction of a second in an atomic reactor if no means were provided to keep the reaction in

check. The fastest and most delicately adjusted control system in the world could not keep the reaction within bounds. In an instant the nuclear pile would explode as a super atomic bomb.

Luckily, however, nature herself has provided a natural control. Not all of the neutrons emitted in the fission process are ejected immediately. Quite early in the investigation leading to the development of the atomic bomb, it was known that about 1 per cent of the neutrons emitted were not ejected immediately but were given off in decreasing quantity over a period of time. About 0.7 per cent are delayed by as much as a minute, others by 0.01 second. This delay gives a sort of inertia to the chain reaction that greatly facilitates the control. If the effective multiplication factor of the pile becomes slightly greater than one, the neutron density does not rise to harmfully large values instantly, instead it rises gradually so that there is a chance for the control rods to operate. Despite the action of the delayed neutrons, the action is still very fast and great precaution has to be taken to assure absolute certainty of control. There can be no failure of the control system in the operation of an atomic reactor.

The control of the nuclear reactor, despite its delicacy, imposes no formidable obstacles in the design of an atomic power plant, indeed, the control systems worked out for the nuclear reactors now in use in the production of plutonium will probably be satisfactory for the reactors used in power plants.

A problem of extreme importance and one that will be very difficult to solve is the "canning" problem. This involves the use of cans or envelopes in which to enclose the uranium, so as to separate the uranium from the cooling medium. The uranium cannot be in contact with the cooling medium since it might react chemically and give trouble. The "canning" problem, in fact, was one of the most difficult to solve in the original design of the Hanford piles, yet, there, because of the low temperature at which these piles operate, the problem was comparatively simple. In the Hanford piles, aluminum cans were used. These fit closely around the uranium, do not absorb an excessive amount of neutrons, and are effective in transmitting the heat generated in the uranium to the coolant.

In the nuclear reactor for power purposes, however, the temperature level will be of the order of 1000-2000 F, and since the melting point of aluminum is about 1200 F, it is obvious that this metal cannot be used for this purpose in the power type of nuclear pile. For effective heat transfer, there must be close, intimate contact between the uranium and the walls of the can. Perhaps an entirely different solution is required.

While a great deal of the heat is produced in the uranium rods, heat is also produced in the moderator. The heat produced in the nuclear reactor is the result of the explosion of the uranium-235 nucleus. As a result of slow neutron capture, the nucleus flies apart violently and in the process of rupture some of the mass of the nucleus is converted into energy. The energy so released is very great—far greater than anything we are familiar with in ordinary chemical reactions.

Let us compare the energy release in the nuclear reactor with that obtained in the burning of coal. The heat release from the burning of coal is usually measured in Btus. A Btu—the heat required to raise a pound of water one degree—is not a very large unit, yet it is extremely large compared to the electron volt used to express the energy release in nuclear fission. It takes 6650 million, million, million electron volts to make a single Btu! To produce 13,600 Btu per pound, a pound of coal containing 230 times 10_{23} atoms will give off energy at the rate of *4 electron volts per atom.*

Compare this with what happens in the nuclear reaction. Here, also, the uranium gives off energy, atom by atom but in this case each atom gives off not 4 electron volts but *200 million electron volts!* Thus, in the nuclear reaction uranium releases 50 million times as much heat per reacting atom as does coal in ordinary combustion. This, actually works out to be 3 million times as much heat per pound.

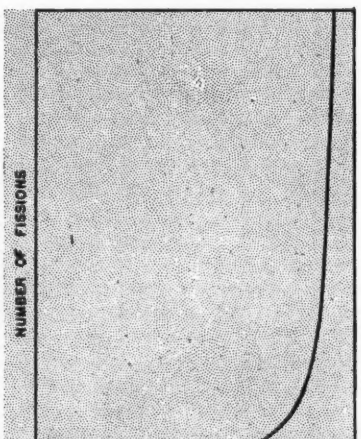


Fig. 3. This curve shows in a dramatic way how the number of fissions in an atomic reactor would multiply, if all the neutrons were emitted instantly; that is, if there were no delayed neutrons

These relations show why nuclear energy is so important as a source of power, and they also show why the question of heat transfer is so important in the development of nuclear power plants. This tremendous quantity of heat must be transferred to some medium that can be used in a thermodynamic cycle.

When the uranium nucleus flies apart, the fragments traveling at 300,000,000 miles per hr crash into the surrounding atoms of uranium. Even this tremendous speed is incapable of shattering the nuclei of the other uranium atoms; only the entrance of a slow neutron into the nucleus can do that. The energy of the high speed fragments, however, is given up to the atoms with which they collide resulting in increased thermal agitation, and a general increase in temperature of the mass of uranium as a whole.

Unless one understands the fundamental nature of the fission process there may be some confusion in regard to the temperatures arising in the process. Fundamentally, temperature is a measure of velocity—velocity of atoms, molecules, electrons, neutrons, etc. For example, the mean speed of a mercury atom in a container at a temperature of 60 C is 0.12 miles per second. This is the ordinary speed due to temperature. Compare this with speeds of from 80,000 to 150,000 miles per second attained in nuclear fission and you get an idea of the temperatures arising as a result of fission. These speeds correspond to temperatures of *many thousands of millions of degrees.*

The meaning of these temperatures must be understood in relation to the operation of a nuclear reactor. Only a very small proportion of the total number of atoms in the uranium rods undergo fission at any one instant. The fragments resulting from the fission of one nucleus, however, crash into and rebound from a great many normal atoms and the increased kinetic energy of all these atoms results in a general rise in temperature of the mass of uranium as a whole. This temperature rise, of course, is of moderate order. If, for example, the energy of one fission, measured say, by a temperature of 10,000 million degrees, is transferred to 10 million other atoms, the resulting temperature rise of the mass may be only 1000 deg. The action is illustrated in Fig. 1. This diagram is an attempt to illustrate the transfer of heat or energy from the fission of a single nucleus of a uranium atom to the surrounding atoms of uranium and the cooling medium. As explained, the vertical axis of this diagram represents the scale of temperature in degrees Kelvin, that is degrees absolute. The horizontal axis represents the

distance from a point in the uranium to a point in the moderator material as indicated in Fig. 2. In this particular illustration it is assumed that the cooling medium will be heated to a temperature of around 1000 deg, roughly the temperature that would be required in the operation of a nuclear power plant.

The circles represent atoms and the distance between them is a rough measure of their thermal velocity. As shown, close to the point where fission occurs in an atom of uranium, the thermal velocity of the atoms is very high. Since the kinetic energy of the fission fragments is given up to millions of surrounding atoms the temperature gradient (kinetic energy gradient) is very steep at first. As more and more atoms become involved, however, the slope of the temperature curve levels off to a temperature of around 1000 or 1200 deg.

The fission fragments, being very massive, do not travel very far; they give up their energy to the surrounding uranium atoms. The neutrons produced by the fission, being small and carrying no electric charge, easily pass through the uranium as well as the walls of the container and the cooling medium until they reach the moderator. In the moderator they are slowed down and drift back into the uranium as slow neutrons where they effect fission in other uranium atoms. In their passage through the moderator, they heat the moderator material as does also the gamma radiation absorbed by the moderator. Thus the moderator material become hot and there is a transfer of heat from the moderator to the coolant.

So, it is evident that the whole process of atomic fission is intimately involved with heat transfer, and, before we can design and build a nuclear power plant, a number of very complex heat transfer problems will have to be solved.

Eighth Annual Water Conference

Three-day conference held in Pittsburgh, November 12, 13 and 14 dealt with purification of waters for industries, boiler scale removal, automatic control, and the problems of stream pollution

SO IMPORTANT to industry has the Annual Water Conference become that this time the Civil Section of the Engineers' Society of Western Pennsylvania, under whose sponsorship the conference is held, arranged for a three-day meeting every hour of which was used to present material of value to water chemists and engineers confronted with water treatment problems. Registration for the sessions numbered nearly 300 persons coming from nearly every state in the United States, as well as a modest delegation from Canada. The Water Conference Committee consists of H. M. Olson, chairman, under whose management this and all previous water conferences have been conducted; Max Hecht, W. J. Murdoch, F. R. Owens, W. M. Porter, Owen Rice, K. F. Treschow and S. F. Whirl.

Subjects of the various papers presented are given in the accompanying list. This report, however, abstracts briefly only those which deal in a practical way with problems encountered by power plant engineers.

Acid Cleaning of Boilers

In relating his experience at the South Omaha Steam Electric Station, with frequent acid cleaning of steam boilers, S. K. Adkins, indicates that there is considerable value in this method of cleaning boilers to the power plant operators as judged from his use of this method during the period between October 1944 and June 1946.

He stated that since the initial operation of this plant in 1938, heavy deposits of sludge have been experienced in both of the boilers which are installed. This necessitated turbining and washing the boilers seven to ten times a boiler per year. The initial acid cleaning of one of the boilers was attempted in October 1944, with a 7½ per cent inhibited hydrochloric acid solution. Temperature of the acid entering the boiler was controlled between 180 and 200 F. Frequent checks of the acid strength during the soaking period were made and showed that the acid strength had decreased to a constant 5.5 per cent at the end of two hours.

The boiler was then drained and re-filled with untreated alkaline city water and again drained. Following this the boiler was re-filled with untreated alkaline city water to which 50 lb of soda ash per 1000 gal of water had been added. The boiler was allowed to soak briefly in this solution and again drained. The boiler was then opened for inspection. All readily accessible internal surfaces of the boiler were examined. This examination disclosed that the surfaces were free from sludge and that no visible corrosion existed.

Identical treatment was given to the second boiler a week later except that a 5 per cent solution of inhibited hydrochloric acid was used. Tests indicated reaction completion at 3 per cent acid strength. Several weeks later the same procedure was followed with the exception that a 3 per cent solution of inhibited hydrochloric acid was used. During these two cleanings, tests indicated that reaction was complete when acid strength had dropped to one per cent. Careful inspection after completion of these washes also revealed clean surfaces and freedom from visible corrosion. Since post cleaning inspections had failed to reveal any visible corrosion up to this time, the soda ash was eliminated from the second rinse. Double rinses with untreated alkaline city water were continued.

Again after seven additional weeks the boilers were acid washed, for the third time, again using a 3 per cent inhibited acid solution. Inspection of both boilers after these washings disclosed occasional patches of adhering sludge, particularly in the downcomer tubes. Although this sludge was readily removed by washing with a high-pressure water hose, it was decided that agitation with compressed air would assist in removing the sludge. Sebsequent cleanings using compressed air introduced through the main blowdown connections, prove this assertion correct. Two hour soaking periods were maintained with the air entering during this period.

Indications of corrosion began to appear in December 1945 after each boiler had been cleaned nine times at intervals of from 6 to 10 weeks. After an investigation of three different inhibitors at various concentrations being studied, all acid cleanings during April 1946 and June 1946 were conducted with double the usual inhibitor concentration and the temperature 160 F. In spite of this precaution, however, handhole gaskets continued to fail after each cleaning. Plans were made to alternate turbining and acid cleaning in an effort to arrest the action and the last acid cleaning was performed in June 1946. At this time each boiler had been cleaned 14 times within a period of 22 months.

Following this experience the treatment of boiler water was changed to the use of a high alkalinity chemical and it is indicated that the necessity for acid cleaning or turbining of these boilers has been permanently precluded. Based on the experience described, the author is of the opinion that the following factors are of utmost importance when acid cleaning boilers:

(Continued on page 122)

Estimating Voltage Drops Caused

Part III. This is the third and final part of Mr. Boice's article on estimating voltage drops. In this last installment he takes up the matter of the torque characteristics of motors. Also he gives two examples showing how the principles discussed in his article are actually put into effect

By W. K. BOICE

Industrial Power Division, General Electric Co., Schenectady, N. Y.

IN PART 2 of this article, published in the January issue, consideration was given to the various voltage drops encountered in distribution and power systems. Now, in this final part, we will consider the torque characteristics of motors and also will show by means of examples, how the methods discussed in this article are actually put into effect.

First, we will take up the question of available motor torque. It is advisable to compare the expected load torque with the estimated torque available from the motor. This torque will be less than the guaranteed full-voltage torque if the voltage drop in the system is appreciable. Starting and pull-in torques of induction and synchronous motors approximately vary as the square of the applied voltage. For example, these torques are 64 per cent of their specified full voltage values at 80 per cent voltage.

Any method of reduced voltage starting will reduce the starting torque available from the motor. This should always be taken into consideration when using reduced voltage starting.

In order to properly apply motors, it is necessary to know in advance the torque required by the load during starting and at pull-in. Some loads, such as pumps and fans, often require a very small torque for starting, but their loads increase with speed so that the motor may not be able to reach full speed. If it is a synchronous motor, it may not pull in. At all speeds between standstill and full speed, the motor available torque should exceed the load torque by enough to cause adequate acceleration. Consequently, it is necessary to know the complete torque-speed characteristics of such loads.

Motor Torque-Speed Characteristics

Figure 1 shows typical torque-speed characteristics for a synchronous motor for several conditions. Torque-speed curves for a representative fan or pump load are also included. Curve A is the motor full-voltage torque-speed curve. Curve B shows the torque when started by a full-voltage starter, from a power system with an appreciable voltage drop. Curve C shows the effect of using a reduced voltage autotransformer type starter, on the 65 per cent tap, connected to the same power system. The line currents corresponding to the two methods of starting are shown by Fig. 2, and the corresponding line voltages by Fig. 3.

Knowing the current values from the full-voltage current-speed curve (Curve A, Fig. 2) the voltages at the motor starter can be calculated by the methods given in this article. For the reduced voltage starter, the motor voltage will, of course, be less in proportion to the tap used.

Sometimes torque data is given in lb-ft. Such values can be converted to the corresponding per cent values based on the motor rating by use of the following formula:

$$\text{Per Cent Torque} = \frac{(\text{Torque in lb ft})\ (\text{Rated rpm})\ 100}{5250\ (\text{Rated hp})}$$

Load Torque Characteristics

Curve D, Fig. 1 shows a centrifugal fan or pump load characteristic when started with the discharge valve open. In this case full load is delivered as soon as the drive reaches full speed. Comparison of Curves C and D show that the motor will not accelerate above 65 per cent speed if the reduced-voltage starter is used. To avoid this difficulty, the motor may be started by a full-voltage starter, or the load torque may be reduced. Curve E, Fig. 1, shows the result of reducing the load by starting with the discharge valve closed. In this case, the motor easily accelerates to nearly full speed, because the load torque at full speed is only about 50 per cent of normal. The curves of Fig. 1 illustrate the importance of knowing the torque-speed characteristics of motor and load in advance.

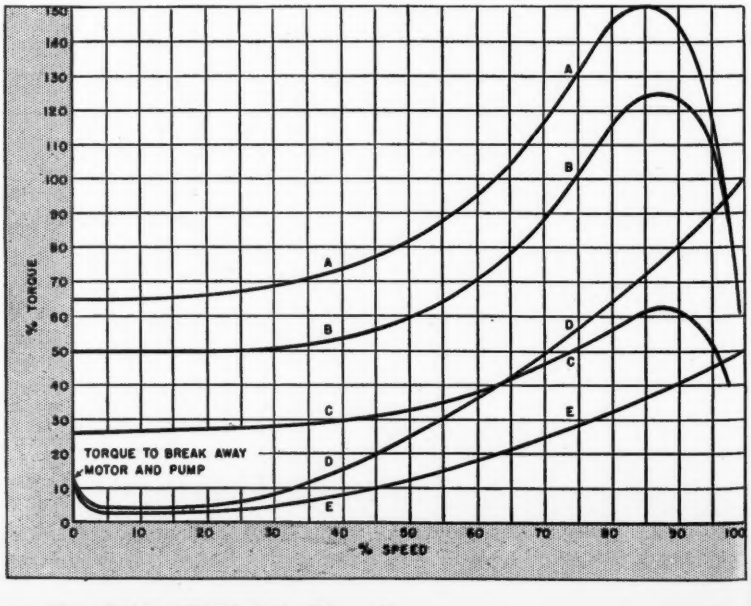


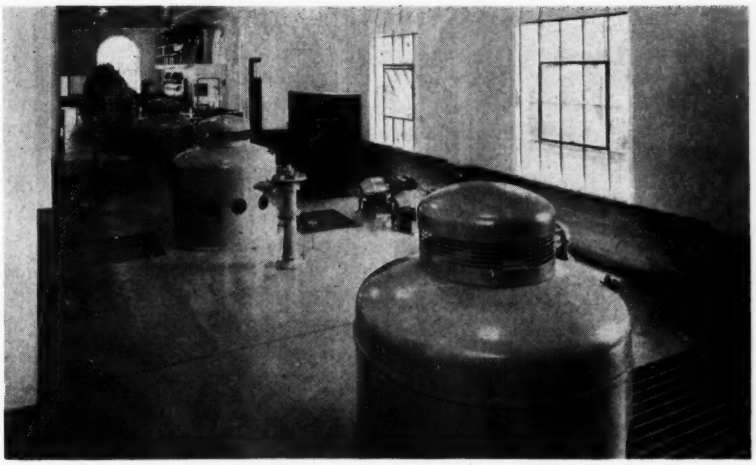
Fig. 1. Torque speed characteristics

A—Motor torque at rated motor voltage
B—Motor torque using full voltage starter connected to power system, showing effect of system voltage drop
C—Motor torque on 65 per cent autotransformer tap, supplied from same power system
D—Pump torque with discharge open
E—Pump torque with discharge closed

By Starting A-C Motors

Time to Accelerate

From standstill all the way to full speed (or pull-in speed), the motor torque should exceed the load torque by at least 5 per cent of rated torque, and the excess should be greater in the case of loads with appreciable inertia. An accelerating torque of 5 per cent will accelerate a motor to nearly full speed in about 20 seconds or less, if the load has no inertia. The motor is not likely to be overheated by the starting current during this time. If the load inertia is equal to the motor inertia, the accelerating torque should be at least 10 per cent. For high inertia drives, it is desirable to obtain the load inertia and load torque characteristics and check with the motor manufacturer regarding accelerating torque needed to prevent overheating the motor during starting of this load.



Group of synchronous motors in pumping plant

Pull-in Torque

In the case of a synchronous motor, it is not only important to consider the breakaway torque and accelerating torque, but also the pull-in torque. This torque is greatly affected by the voltage just before pull-in. Fortunately, the voltage drop at this time is normally much less than at the time of starting, because the line current is usually about one-half of the full-voltage starting current. In order to determine accurately the voltage just before pull-in it is necessary to know the speed to which the motor is accelerated. This can be determined from the torque-speed characteristics as the speed of the intersection of the torque-speed curves of the motor and load. For load curve D and motor curve B of Fig. 1, this is seen to be 97 per cent speed.

The speed just before pull-in is usually above 95 per cent, and the current at 95 per cent speed may be used as a conservative estimate of the current, for the purpose of estimating voltage before pull-in.

The load torque at 100 per cent speed is the required pull-in torque. The available pull-in torque is approximately equal to the full-voltage pull-in torque times the square of the actual voltage. The pull-in torque is not shown on the torque-speed curves for the motor. Manufacturers provide guaranteed values of pull-in torque for stated amounts of load inertia (WK^2), based on rated motor voltage at the terminals. Hence with 90 per cent voltage just before pull-in, and a guaranteed pull-in torque of 50 per cent, the available torque is approximately 40 per cent, since 50 per cent $\times$ (90 per cent)^2 = 40 per cent.

It should be noted that reduced voltage starting equipment is usually cut out of the circuit before pull-in so that the effect of this equipment need not be considered at this time. In the case of reactor starters, for motor-generator sets, field is applied before cutting out the reactor, but pull-in torque requirements of these sets are so low that this procedure is satisfactory and has the advantage of minimizing the line current for pull-in.

Reduced Frequency Starting

Occasionally in order to start a large motor, the system frequency is reduced to a low value in order to increase the motor torque. At reduced frequency the applied voltage is lower but, in the usual application of the scheme, the applied voltage is only reduced to the same extent as the frequency, i.e., the generator excitation is maintained at the same value as before. Motor torque varies with reducing frequency in the same way as it does with increasing speed, since in either case the rotor frequency is reduced. Consequently, at 10 per cent frequency, the torque delivered will be approximately that equal to the torque at 90 per cent speed. This, of course, approaches the motor maximum torque. Unfortunately, at these low frequencies the effective line resistance is greatly increased, so that all of this torque is not realized. Nevertheless, the scheme will effectively increase the torque available for starting and accelerating the motor. However, there are several disadvantages which usually make it impractical.

1. The frequency must be reduced to a very low value, i.e., below 50 per cent frequency, which is difficult for some types of generator drives.

2. At low generator speeds, direct-connected exciters, or a-c motor driven exciters, will not provide sufficient excitation.

3. Lowering the system frequency may adversely affect other equipment connected to the system.

Consequently, the scheme is usually applicable only for a generator supplying a single motor when excitation is supplied by an exciter driven by a separate steam-turbine, or an equally independent excitation source. In such cases, the scheme may be quite advantageous.

Table 1. Power system short circuit kva

System Voltage	Usual Range of Short Circuit kva
2400	15,000- 150,000
4160	25,000- 250,000
6900	50,000- 500,000
13,800	100,000-1,000,000
23,000	150,000-1,500,000
34,500	150,000-1,500,000
69,000	150,000-1,500,000
115,000	250,000-2,500,000

Example 1 (See Fig. 4)
Data

Power System
Short circuit kva—50,000 kva (minimum)

Transformer Bank
Rating—300 kva, 3-phase, 60-cycle
Primary Tap Setting—2400 v
Transformer Ratio—2400/480 v

Induction Motor
Output Rating—100-hp
Rated Voltage—440 v

Full Voltage Starting Inrush—570 kva (750a at 440 v)
Full Voltage Starting Torque—125 per cent

INITIAL CONDITIONS

Initial secondary voltage = 440 v (At motor starter). (This allows for effect of 100 kva initial load on the bank which is assumed to be constant-current type)

REQUIREMENTS

1. Voltage should not dip below 70 per cent of 440 v = 308 v (to keep running motors going, and avoid contactor dropout). Light flicker not important.
2. Load on motor requires 25 per cent starting torque (machine tool)
3. Full voltage starting desired

CALCULATIONS

Motor starting load applied to transformer bank
= 570 kva
= 190 per cent of bank rating (300 kva)

Transformer secondary voltage (neglecting power system drop), is obtained from Fig. 1, (Part II) using curve for banks rated below 15 kv. It is 91 per cent, of initial voltage, for a motor starting load of 190 per cent

Motor starting load applied to power system
= (motor starting kva on bank) (per cent secondary voltage)
= 570 × 91 per cent = 520 kva

Per cent System voltage drop = $\frac{\text{(Motor starting kva)} \times 100\%}{\text{(Short-circuit kva)} + \text{(Motor starting kva)}}$
= 1 per cent

Minimum voltage at motor = 91 per cent × 99 per cent
= 90 per cent of 440 v (initial voltage)
= 396 v

Available starting torque = (full voltage starting) (per cent motor voltage)^2
= 125 per cent (90 per cent)^2 = 101 per cent

CONCLUSIONS

Minimum voltage (90 per cent) and available starting torque (101 per cent) are adequate to meet requirements

EXAMPLE 2 (See Fig. 5)

DATA

GENERATORS

2 identical turbine-driven generators, 3600 rpm
Total output rating = 10,000 kva
Voltage rating = 6900 v
Voltage regulator setting = 6700 v

OVERHEAD LINE

Insulation class = 7500 v
Length = 5000 ft
Conductor size = 4/0

TRANSFORMER BANK

Output rating = 2000 kva (3-phase)
Transformer ratio = 6600/2400

MOTOR STARTER

Autotransformer type
Tap = 65 per cent

MOTOR

Synchronous motor
Output rating = 1000 hp
Input rating = 1000 kva, 0.8 p f
Rated voltage = 2200 v
F.V. Pull-in Torque = 100 per cent
F.V. Starting kva = 500 per cent (See also Curve A, Fig. 2)
F.V. Starting Torque = 70 per cent (See also Curve A, Fig. 1)

LOAD ON MOTOR

Centrifugal pump with torque-speed characteristic given by Curve E, Fig. 1. (Pump started with valves closed)

INITIAL CONDITIONS

INITIAL VOLTAGES

At Generator Bus = 6700 v (regulator setting)
At Transf. Primary = 6600 v (allows for effect)
At Transf. Secondary = 2350 v (of initial load)

INITIAL LOADS

At Generator Bus = 5000 kva (50 per cent of Gen. rating)
At Transf. Secondary = 1000 kva
Initial load assumed to be constant-current type

REQUIREMENTS

Minimum allowable generator voltage—90 per cent of initial voltage
Motor torques must be adequate for acceleration and pull-in

VOLTAGE CALCULATIONS

Starting input to autotransformer, for rated motor voltage, = (motor full voltage starting kva) (multiplier from Table I, Part I, for 65 per cent tap) = 5000 × 0.46 — 2300 kva, for 2200 v

Motor starting load applied to transformer bank = (inrush kva at 2200 v) ×

$$\left(\frac{\text{initial secondary volts}}{2200}\right)^2$$

$$= 2300\left(\frac{2350}{2200}\right)^2 = 2630 \text{ kva}$$

= 131 per cent of bank rating (2000 kva)

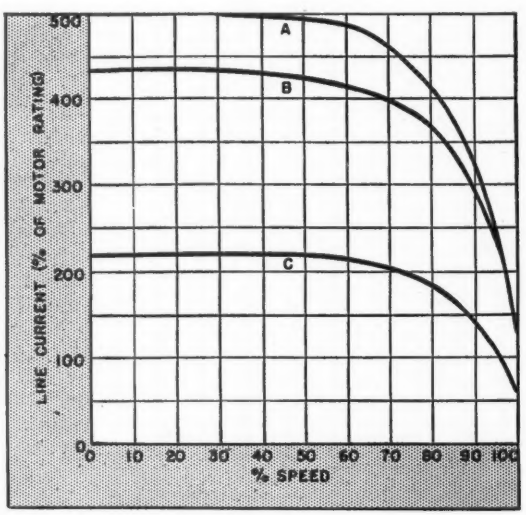


Fig. 2. Line current

A—At rated motor voltage
B—With full-voltage starter connected to power system, showing effect of system voltage drop
C—With autotransformer on 65 per cent tap, connected to same power system

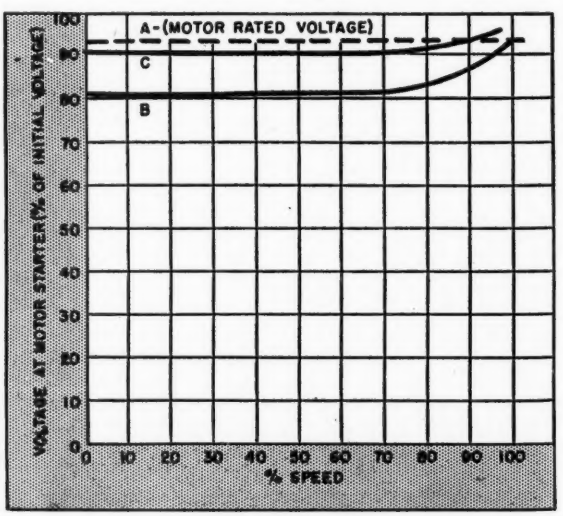


Fig. 3. Line voltage

A—Motor rated voltage
B—With full-voltage starter connected to power system, showing effect of system voltage drop
C—With autotransformer on 65 per cent tap, connected to same power system

Transformer secondary voltage (neglecting primary voltage drop) is obtained from Fig. 1 in Part II for banks rated below 15 kv. It is 93.5 per cent

Motor starting load applied to transmission line = (motor starting kva on bank) (per cent secondary voltage) = 2630 × 93.5 per cent = 2460 kva

Motor starting loading factor on line, M = (motor starting kva)

$$\left(\frac{\text{length in feet}}{\text{initial volts}}\right)^2 = \frac{2460 \times 5000}{6600 \times 6600}$$

$$= 0.282$$

Motor starting voltage drop in line for M = 1, is obtained from Fig. 3 in Part II, for 4/0 line for 7500-v insulation class. It is 11.5 per cent. Since M = 0.282, Drop in line = 11.5 per cent × 0.282 — 3.4 per cent. Voltage at end of line (neglecting generator drop) = (100 per cent — 3.4 per cent) = 96.6 per cent of initial voltage (6600 v)

Motor starting load applied to generators
= (motor starting kva on line) (per cent line voltage)
= (2460) (96.6 per cent) = 2370 kva
= 23.7 per cent of total generator rating (10,000 kva)

Performance factor, K, of generators is determined from Fig. 4, Part I. It is 1.9 for 5000 kva generators at 50 per cent initial load

Minimum voltage of generators is determined from Fig. 3, Part I. It is 93.5 per cent of the initial generator voltage (6700 v), for 23.5 per cent motor starting kva, and K = 1.9
(Note that this is higher than minimum allowed)

Restored generator voltage (for providing breakaway torque) is determined from Fig. 5, Part I. It is 100 per cent of initial voltage (6700 v) for motor starting kva of 23.5 per cent and initial load of 50 per cent

Restored voltage at motor starter (for providing breakaway torque) = (per cent generator restored voltage) (per cent line voltage) (per cent secondary voltage)
= (100 per cent) (96.6 per cent) (93.6 per cent) = 90.2 per cent of initial starter voltage (2350 v)

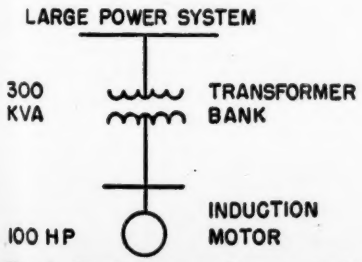


Fig. 4. Circuit diagram of power supply to motor (Example 1)

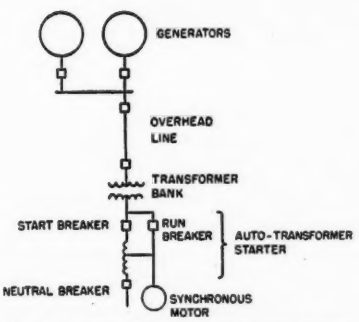


Fig. 5. Circuit diagram for power supply to motor (Example 2)

= 96.2 per cent of motor rated voltage (2200 v)

Motor-voltage for breakaway torque
= (Starter voltage) (autotransformer tap)
= (96.2 per cent) (65 per cent)
= 62.5 per cent of 2200 v

ACCELERATING TORQUE CALCULATIONS

Breakaway Torque
= (Full voltage starting torque) (Per cent motor voltage)²
= (70 per cent) (62.5)² = 27.4 per cent
(Note that this is sufficient to meet required torque)

Accelerating torques are calculated in same manner as breakaway torque, except using proper valve of input kva to the starter for each of several valves of motor rpm. Results are plotted as follows:
Line Voltage (at starter)—Curve C, Fig. 3
Motor Torque—Curve C, Fig. 1

Curve C, Figure 1, gives torque values at all speeds up to 94 per cent speed, which give at least 10 per cent torque margin for acceleration. This is probably adequate since a centrifugal pump usually does not have inertia higher than that of the motor.

At this speed (94 per cent), transfer to the running connection will increase the input kva, to the starter, to 260 per cent of 1000 kva, for 2200 v (From Curve A, Fig. 2). This means a sudden change of about 160 per cent which is less than the input at start (2350 kva) so it will not cause the generator voltage to dip below the allowable minimum. Hence, the autotransformer tap is high enough to avoid an excessive dip at the time of transfer to the running connection.

PULL-IN TORQUE CALCULATIONS

The motor voltage at pull-in is estimated by calculating the restored motor voltage as above, except at 95 per cent speed with motor connected directly to line (autotransformer out). This voltage is 95 per cent of 2200 volts.

Available pull-in torque
= (rated, full voltage, pull-in torque) (motor voltage)²
= (100 per cent) (95 per cent)²
= 90 per cent
This is adequate since the load only requires 50 per cent torque at 100 per cent speed. (From Curve E, Fig. 1).

CONCLUSIONS

The minimum generator voltage, breakaway torque, accelerating torque, and pull-in torque are all adequate to meet requirements.

GAS-DIESELS CUT FUEL COST 55% IN TEXAS

STRAIGHT DIESEL engine fuel costs can be reduced by 55 per cent by using the gas-diesel principle in the Southwest part of the country, according to a survey just completed by Cooper-Bessemer Corp. engineers.

In the city of Burkburnett, Texas, for example, where the municipal power plant uses a Cooper-Bessemer Type JS-8-cylinder engine, rated at 675 hp at 400 rpm, fuel savings have been at the rate of $800 less per year for gas-diesel operation than for straight natural gas operation and at the rate of $6,100 less than for straight diesel operation.

The city of Liberty, Texas, which uses a Cooper-Bessemer Type GS-6-cylinder gas-diesel, rated 300 hp at 450 rpm, has recorded a fuel saving at the rate of $3,860 per year under straight diesel operation and $365 per year under straight natural gas operation by employing the gas-diesel principle. The city also operates two Cooper-Bessemer Type GN-6-cylinder, 300 hp gas engines.

The Burkburnett figures are predicated on a yearly load division of 20 per cent at one-quarter load; 30 per cent at half load; 40 per cent at three-quarters load and 10 per cent at full load. Fuel oil there now costs 6⅛ cents per gallon and the cost of natural gas is 20 cents per 1000 cu ft for the first 2,000,000 and 15 cents per cu ft for all over 2,000,000 each month.

A breakdown of the Burkburnett fuel costs since it began its gas-diesel operation show savings of 19.5 per cent under straight diesel operation and 8.8 per cent savings under gas at one-fourth load. At one-half load, the gas-diesel operation costs 46.8 per cent less than straight diesel and 9.2 per cent less than gas. The fuel savings at three-fourths load are even more impressive, showing savings of 53.8 per cent under diesel cost and 12.7 per cent under gas. The largest percentage of savings, however, is under full load, this being at the rate of 59.5 per cent less than diesel cost and 19.3 per cent under gas operation.

The Liberty figures were compiled on the basis of a 20 per cent operation at one-fourth load; 30 per cent at one-half load; 40 per cent at three-quarters load, and 10 per cent at full load.

The Gas Turbine Power Plant—VIII

How the gas turbine power plant may be used in industry . . . Coal-burning gas turbine more important if oil and gas become scarcer and costlier . . . Gas turbine plants can produce power, heat and cold for industry . . . Simple cycle gives thermal efficiency of 24 per cent for power alone, 56 per cent when producing steam from waste heat . . . Detailed calculations given for various conditions of power and heat supply . . . Water problem . . . Comparison of steam and gas turbine plants . . . Gas and steam turbine combinations . . . Gas turbine refrigeration cycles . . . This is the last of the series of eight articles on this subject beginning in the January, 1947, issue; they will soon be collected and somewhat rearranged and republished in book form

By JOHN I. YELLOTT

Director of Research, Locomotive Development Committee, Bituminous Coal Research, Inc.

USEFULNESS of the gas turbine power plant in industrial applications will depend upon its ability to produce, by burning low-cost fuels, a wide variety of combinations of power, steam or other vapors for process and space heating, refrigeration and compressed air. Previous articles in this series have dealt particularly with the gas turbine as a power generator. In industry, however, the supplying and removal of heat are frequently of greater value and importance than the generation of electrical power.

An analysis of the problems that will confront power engineers in the near future must begin with the realization that liquid and gaseous fuels are certain to rise in cost as their availability diminishes, while coal, because of its abundance, as shown in Fig. 1, will continue to be the cheapest source of energy. The science of petroleum cracking has now developed to the point where virtually all of the barrel of crude can be converted into gasoline and distillate oil for Diesel engines and home heating. Residual oil is not likely to remain available at low cost, because it can be upgraded into higher valued fuels.

The United States will never run out of liquid fuels, for they can be synthesized from coal, but only at a cost which will be quite close to that of gasoline at the refinery. Synthetic fuel from natural gas will be a reality in the relatively near future, but, in the long run, America's fuel requirements will be met from her inexhaustible coal reserves (1). Importance of the coal-burning gas turbine is greatly enhanced by the current trends in price and scarcity of the two competitive fluid fuels, residual oil and natural gas.

Another item that will be scarce in the predictable future is good water. Already the major metropolitan areas of the United States are dependent upon long aqueducts, and most cities require that cooling towers be used with condensing steam plants, air conditioning systems, and other water-consuming equipment. In very few locations today can unlimited supplies of good water be obtained by the simple process of drilling a well or dropping a pipe into a lake or river. A power plant that can utilize the cheapest available fuel at good efficiency without requiring water for condensers or radiators will find applications in many parts of the United States, and particularly in the central and western states.

A third factor to be considered is the growing importance of refrigeration in industrial and institutional power plants. Comfort air conditioning is rapidly becoming a necessity rather than a luxury, while air treatment and refrigeration are essential in many of the process industries. The gas turbine plant can produce "cold" as well as heat, either by the use of expansion turbines or by combinations with mechanical and absorption refrigeration.

Heat and Power Cycles

The components of the gas turbine plant—compressor, combustor, heat exchanger, and turbine—are capable of being arranged in a wide variety of combinations to produce a desired result in terms of power, heat, and refrigeration. The remainder of this article will discuss some of the possible arrangements suggested for the solution of particular problems.

The simplest arrangement for supplying both heat and power is the open-cycle plant with a waste heat boiler in place of a regenerator. Figure 2 shows how such a plant might be arranged, using coal, oil, or gas as economic conditions dictate. An excellent summary of the possibilities of this and other more complicated cycles was given by Messrs. L. N. Rowley and B. G. A. Skrotski at the 1947 Midwest Power Conference (2). Pfenninger of Brown Boveri has also published an analysis of similar cycles. The performance of the plant at an assumed full load of 5000 hp is given in Table I. A pressure ratio of 8 to 1 was selected to give good thermal efficiency without using a regenerator, while a turbine inlet temperature of 1350 F was chosen because metals or cooling methods will ultimately be available, which will permit such temperatures to be used without unduly shortening the life of the turbine.

The simple cycle of Fig. 2 can give a thermal efficiency of 24 per cent for power generation alone, and 56 per cent when credit is taken for the steam generated by the waste heat boiler. The only water involved in the system is that required by the boiler, for no cooling or condensing is needed. It is seen in Table I that the energy sent out in the form of

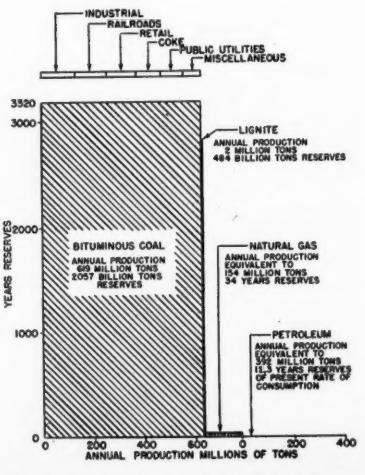


Fig. 1. Fuel reserves of the United States

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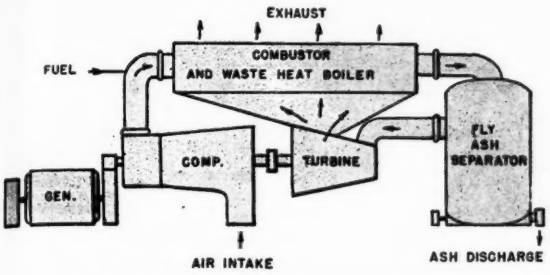

Fig. 2. Simple gas turbine with waste-heat boiler

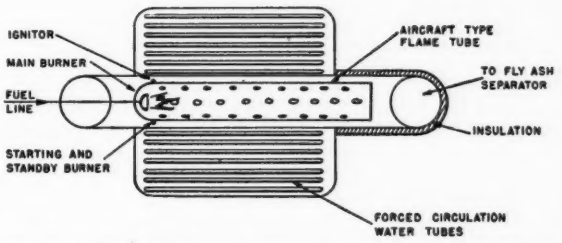

Fig. 3. Section through combustor and waste-heat boiler of Fig. 2

shaft power is about 60 per cent of that in the steam. A possible parallel arrangement of combustor and steam generator is shown in Fig. 3.

Comparison of Steam and Gas Turbine Plants

Any number of 5000-hp steam plants can be designed for comparison with the gas turbine. Table II summarizes a rough approximation of the performance of a straight condensing plant, and a condensing plant with extraction at 100 psia to provide heat equivalent to that contained in the waste heat boiler output. Steam conditions are taken as 400 psia, 800 F at the turbine inlet and 1 in. Hg abs at the condenser. Higher inlet conditions would not be used with such a small plant, nor would elaborate heat recovery apparatus be justified. The steam turbine efficiency is taken as 77 per cent, because of its small size, while the gas turbine, being actually a 15,000 hp unit (232,000 $\times$ 165 $\div$ 2545 = 15,000 hp) would in all probability reach the 87 per cent used in Table I. The steam plant's boiler efficiency is taken as 83 per cent, because neither economizer or air preheater would be used in such a small boiler.

When the demand for heating and process steam is high, and power requirements are low, the non-condensing steam plant is usually the most economical solution to the problem. When, however, power is as important as heat, the gas turbine plant appears to have excellent possibilities. In comparing the steam plant of Fig. 4 with the gas turbine plant of Fig. 2, it is obvious that the gas turbine will have a tremendous advantage in simplicity, compactness, maintenance and freedom from water requirement. First cost is difficult to estimate for the gas turbine plant, and it may well develop that industrial practice in the United States will follow the Swiss policy of restricting turbine inlet temperatures to relatively moderate values where metallurgical problems are not severe.

It should be realized that the gas turbine plant will be expensive as long as such high turbine inlet temperatures are used that very costly alloys and machining processes are essential. When waste heat recovery is used, the maximum attainable

Table I. Performance of open-cycle gas turbine plant with waste heat boiler

ASSUMPTIONS: Inlet temperature = 70 F; 0.2 psi pressure loss in air intake line; 8 to 1 compression ratio; 4.0 psi pressure loss in combustor and ash eliminator; $E_C = 84\%$; $E_T = 87\%$; 5% loss in combustor; 1.3 psi pressure loss in waste heat boiler.

1. Compressor: $t_{C1} = 70$ F; $h_{C1} = 31.2$ Btu per lb
   Actual $t_{C2} = 750$ F; $h_{C2} = 153.2$
   Actual work in compressor = 122 Btu per lb
2. Combustor: $t_{B2} = 1350$ F; $h_{B2} = 357.2$ Btu per lb
   Heat added in combustor = 357.2 — 153.2 = 204 Btu per lb
3. Turbine: $p_{T1} = 112$ psia; $p_{T2} = 16$ psi; ratio = 7 to 1
   $t_{T1} = 1350$ F; $h_{T1} = 357.2$
   $t_{T1} = 1350$ F; $h_{T1} = 357.2$
   Actual $t_{T2} = 724$ F; $h_{T2} = 192.0$
   Work done per lb = 357.2 — 192.0 = 165.2 Btu per lb
4. Net work to shaft = $\Delta h_T - \Delta h_C$ = 165.2 — 122.0 = 43.2 Btu per lb
   Air rate = 2545 $\div$ 43.2 = 59.0 lb per hp hr
   Air flow = 5000 $\times$ 59.0 = 295,000 lb per hr
5. Approximate heat balance:

Heat supplied to cycle = 295,000 $\times$ 204 $\div$ 0.95	= 63,700,000 Btu per hr
Combustor loss, 5%	= 3,190,000
Heat to shaft power = 295,000 $\times$ 43.2	= 12,700,000
Heat to exhaust, balance	= 47,810,000

6. Efficiency for power alone:
   E_c = (12,700,000 $\div$ 63,700,000) $\times$ 100 = 20%
7. Waste heat boiler:
   p = 100 psia, saturated; t_s at 100 psia = 328 F
   Allow 100 F for terminal difference between steam and exhaust leaving boiler at 428 F; $h_{a1r} = 118$
   $\Delta h_{a1r} = 192 - 118 = 74$ Btu per lb air
   Total Btu recovered = 295,000 $\times$ 74 = 21,800,000 Btu per hr
   Assuming feed water at 79 F, $h_f = 47$ Btu per lb steam
   h_g at 100 psia = 1187 Btu per lb steam
   Steam generated per hr = 21,800,000 $\div$ (1187 — 47) = 19,100 lb
8. Over-all thermal efficiency:
   E_c = (12,700,000 + 21,800,000) $\times$ 100 $\div$ 53,000,000 = 65%

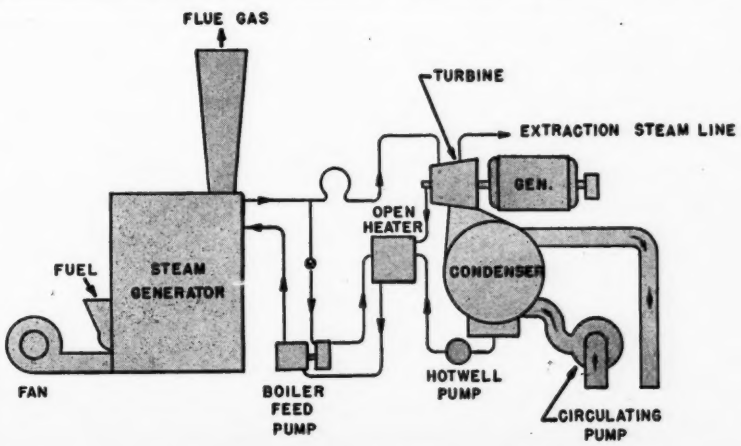

Fig. 4. Arrangement of condensing and extraction steam plant

Table II. Approximate performance of 5000-hp steam plant

A. **Straight Condensing**—$p_1 = 40$ psia, $t_1 = 800$ F; $p_2 = 1$ in. Hg
   1. Assume turbine efficiency = 77%; boiler eff. = 83% $h_1 = 1417$ Btu per lb; ideal enthalpy drop to p_2 (1 in. Hg) = 512 Btu per lb; actual $h = 0.77 \times 512 = 394$ Btu per lb
      Steam rate $= 2545 \div (512 \times 0.77) = 6.44$ lb per hp hr
      Steam required per hr $= 5000 \times 6.44 = 32{,}300$ lb
   2. Heat added in boiler $= (1417 - 47) = 1370$* Btu per lb
      $E_{cycle} = (2545 \times 0.83) \div (6.44 \times 1370) = 24.0\%$
   3. Condenser must remove (1023 — 47) Btu per lb of steam $= (32{,}300 \times 976) = 31{,}500{,}000$ Btu per hr; with a 10 F rise in temp 3,150,000 lb of circulating water would be needed per hr

B. **Extraction of 100 psi steam** (to equal waste heat steam produced by gas turbine)
   1. Using same conditions as in A, steam is superheated at point where the condition curve crosses the 100 psi line, h = 1300 Btu per lb approximately, so amount to be extracted for equivalent heat supply is $16{,}000 \times 1300 \div 1187 = 13{,}700$ lbs
   2. To find total steam flow to turbine (W_T) required to yield 5000 hp, with 13,700 lb extracted at 100 psia,
      $W_T = (12{,}750{,}000 + 3{,}800{,}000) \div 394 = 42{,}000$ lb per hr
   3. Heat added in boiler $= 42{,}000 \times 1370 = 57{,}600{,}000$ Btu per hr
      Heat supplied by fuel $= 57{,}600{,}000 \div 0.83 = 69{,}300{,}000$
      Heat to useful work $= 5000 \times 2545 = 12{,}750{,}000$
      Heat in bled steam $= 13{,}700 \times 1300 = 17{,}800{,}000$
      Over-all thermal efficiency:
      $(12{,}750{,}000 + 17{,}800{,}000) \times 100 \div 69{,}300{,}000 = 44\%$
   4. Condenser must handle 42,000 — 13,700 = 28,300 lb steam per hr
      Cooling water needed per hr $= 28{,}300 \times 973 \div 10 = 2{,}750{,}000$ lb

*No credit allowed for feedwater heating.

thermal efficiency, and the high turbine temperatures required to reach that efficiency, become less important than economy in first cost. At least one American manufacturer is now prepared to offer gas turbine plants on a firm price and guarantee basis, as long as inlet temperature remains below 1150 F.

When alternating current of fixed frequency is required, a two-shaft cycle will give better part load efficiency than the single shaft arrangement. Figure 5 shows one possible combination, where an intercooler is used, with its heat recovery utilized in heating the feedwater for the waste heat boiler. Auxiliary burners are shown in the waste heat boiler, for supplying small quantities of steam when the turbines are shut down. Fuel oil can also be burned in such a boiler, when the turbines are operating at light load, to generate additional steam. Table III shows what such a plant might accomplish when it is producing 5000 hp at the generator coupling.

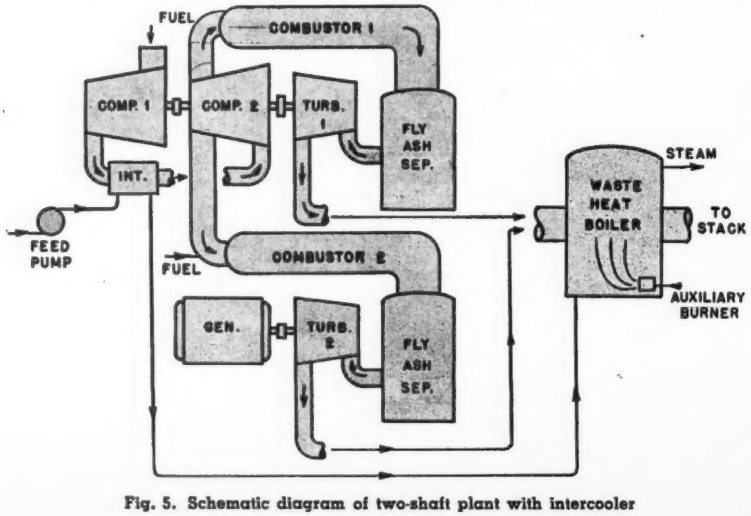

Fig. 5. Schematic diagram of two-shaft plant with intercooler

The heat recovery possibilities of the conventional gas turbine cycle may be summarized by pointing out that the waste heat in the cycle is available at relatively high temperatures, making it suitable for transfer to boiling water or other liquids at moderately high pressures.

Gas and Steam Turbine Combinations

Many proposals have been made for combining steam and gas cycles. Most of these merely complicate the essentially simple gas turbine plant with the addition of steam equipment, without aiding thermal efficiency. As long as no fuel is burned solely for the purpose of evaporating a liquid, but rather all the fuel is used primarily for heating the working gas, the power efficiency of the cycle remains high. When fuel is used to supply latent heat which is not recoverable, thermal efficiency is reduced.

It has been proposed (1) that high pressure steam be generated, as shown in Fig. 6, by forced-circulation coils in the combustor, with at least a part of the steam fed back into the turbine. The water coils would thus serve to aid in cooling the combustor. While added power can be generated without increasing the compressor work with such an arrangement, thermal efficiency suffers.

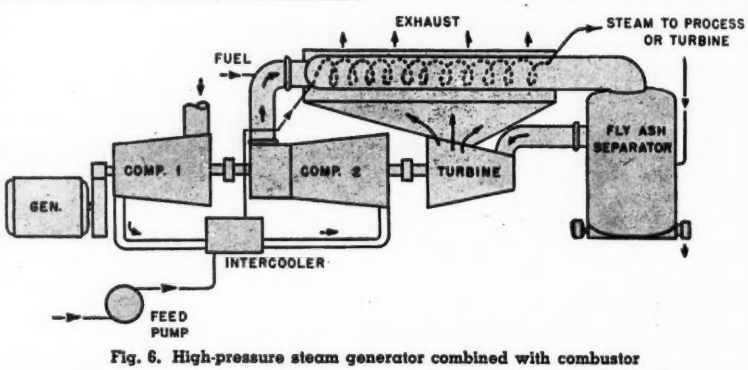

Fig. 6. High-pressure steam generator combined with combustor

A more economical system is shown in Fig. 7. Here a two-cylinder compressor is used, with an intercooler and an aftercooler, which brings the temperature of the compressed air down to as low a value as possible. A regenerator is used to restore to the compressed air at least a part of the heat abstracted by the cooling water. A waste heat boiler is used in combination with the regenerator to generate as much steam as possible at the same pressure as that produced by the two air compressors in series. The steam thus generated is admitted to the combustion chamber where it is superheated and becomes a part of the working gas. In expanding through the turbine, each pound of steam is twice as effective as a pound of air, because the spe-

cific heat of steam is twice that of air. Also, the steam has not used up any compressor work.

The waste heat power cycle of Fig. 7 will be useful for locomotive power plants, which will need train heating steam in winter, but which will be under-powered on hot days or at high altitude. Any number of steam-air cycles can be proposed, but each must be carefully evaluated in the light of particular needs.

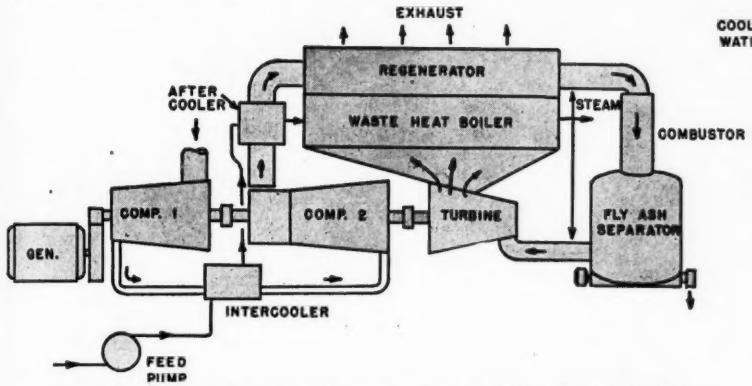

Fig. 7. Steam and gas turbine plant using waste heat for steam generation

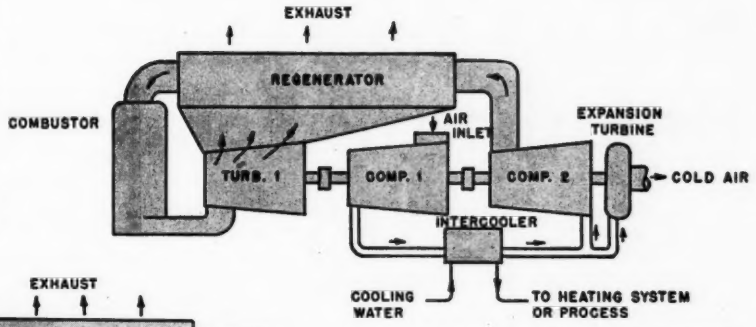

Fig. 8. Gas turbine refrigeration cycle

When air at moderate temperature but fairly high pressure is expanded through a nozzle, the temperature falls and the nozzle becomes cold. If the high velocity is not utilized, the air reheats back to almost the original temperature, and the process is known as "throttling." However, when a heat engine is employed to use the kinetic energy of the high-velocity steam, the air temperature remains low, and sub-zero temperatures are readily obtained. Reciprocating engines can be used to take energy out of the air stream, but small turbines have been developed which can operate as refrigerators without difficulties from packings, lubrication, and so on. Figure 8 shows one possible arrangement which can produce cold air directly from burning fuel without the necessity of using a vapor cycle.

In the particular arrangement shown in Fig. 8, a first compressor, 1C, raises the air pressure to about 60 psia, when its temperature is reduced by an intercooler. Part of the air, depending upon the amount of cold air needed, is bled off through an expansion turbine which helps to drive the compressor. The remainder of the air is compressed to a higher pressure, partially heated by the regenerator, and heated again in the combustor B. This air then expands through the turbine, which supplies the power required by the two compressors. Very low temperatures can be attained by proper combinations of compression and intercooling.

The gas turbine is so new as a practical prime mover that its industrial possibilities are only now being explored. Because it is simple, requires a relatively small amount of space, and is apparently not limited to a particular type of fuel, the gas turbine has excellent prospects as an industrial power generator.

References

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2. "Gas Turbine Possibilities in the Stationary Power Plant Field," by L. N. Rowley and B. G. A. Skrotski; *Power*, June and July, 1947.

Table III. Estimated performance of a two-shaft gas turbine plant with intercooler and waste-heat boiler

Conditions: Same as Table I with $E_{1C} = 80\%$, $E_{2C} = 85\%$, $E_T = 87\%$

1. **Compressors:** Intercool at $p_{1C2} = 41$ psia
   a. First Stage:
      $t_{1C1} = 70$ F $= 530$ R; $h_{1C1} = 31.2$ Btu per lb
      $t_{1C2} = 284$ F; work $= 51.7$ Btu; $h_{1C2} = 82.9$ Btu per lb
      Intercool back to 150 F, 610 R, $h_{2C1} = 50.5$ Btu per lb
      Heat recovered $= 32.4$ Btu per lb of air
   b. Second Stage:
      $t_{2C2} = 391$ F; work $= 59.4$ Btu; $h_{2C2} = 109.9$ Btu per lb
   c. Total compressor work $= 51.7 + 59.4 = 111.1$ Btu per lb
2. **Combustors:** Heat air to $t_{B2} = 1350$ F, $h_{B2} = 357.2$
   Heat added in combustor $= 357.2 - 109.9 = 247.3$ Btu per lb
   With 5% loss, heat supplied $= 247.3 \div 0.95 = 260$ Btu per lb
3. **Turbines:** Inlet pressure $= (8 \times 14.5 = 116) - 3 = 113$ psia
   Back pressure $= 14.7 + 1.3 = 15$ psia; ratio $= 113 \div 15 = 7.54$
   $t_{T2} = 704$ F; $h_{T2} = 187$ Btu; work $= 170$ Btu per lb
4. **Output:** Net work $= 170 - 111.1 = 58.9$ Btu per lb
   Air rate $= 2545 \div 58.9 = 43.3$ lb per hp hr
   Air flow $= 5000 \times 43.3 = 216{,}000$ lb air per hr
5. **Approximate heat balance:**

Heat supplied $= 216{,}000 \times 260.0$	$= 56{,}200{,}000$ Btu per hr
Combustion loss, 5%	$= 2{,}810{,}000$
Shaft power $= 216{,}000 \times 58.9$	$= 12{,}700{,}000$
Intercooler heat recovery, $216{,}000 \times 32.4$	$= 7{,}000{,}000$
Heat to exhaust, balance	$= 33{,}690{,}000$

6. **Heat Recovery:**
   a. Intercooler—assume water entering at 70 F is heated to 250 F in a counter flow heat exchanger; water at 100 psia
      Water heated per hr $= 7{,}000{,}000 \div 180 = 38{,}900$ lb
   b. Steam generator—assume pressure $= 100$ psia, t $= 328$ F; cool air to 428 F, $h_{a1r} = 118$ Btu
      Heat given up by air $= 187 - 118 = 69$ Btu per lb
      Total heat recovered $= 216{,}000 \times 69 = 14{,}900{,}000$ Btu per hr
      If intercooler is used as an economizer to supply water preheated to 250 F, $h_f = 218$, then heat needed to evaporate water $= (1187 - 218) = 969$ Btu
      Steam available per hr $= 14{,}900{,}000 \div 969 = 15{,}400$ lb, in addition to 23,500 lb of water at 250 F
7. **Efficiency:**
   a. Power alone: $(12{,}700{,}000 \div 56{,}200{,}000) \times 100 = 22.7\%$
   b. Power plus heat $(12{,}700{,}000 + 7{,}000{,}000 + 14{,}900{,}000) = (37{,}600{,}000 \div 56{,}200{,}000) \times 100 = 67\%$

Welded Steel Construction for Hydroelectric Power Plants

Proposed new design breaks away from traditional use of concrete . . . Details and costs of a 50,000 kw plant as compared with cost of a similar plant using concrete . . . Gantry crane used instead of usual heavy house crane . . . Advantages in heating and lighting . . . Advantages in equipment handling . . . Savings in various costs

By OWEN J. AFTRETH and ANTHONY J. PERRY

THE CONSTRUCTION of a hydroelectric power plant building has been usually associated with the construction of a large dam. In many cases where the dam is a large concrete structure, it follows that the power plant building is also constructed of concrete. Widely known structures of this type in this country have attained monumental aspects in architectural treatment because they are integral units of large government projects and properly represent achievements of a great nation. The material universally chosen to express these characteristics in the superstructures of the great power plant has been reinforced concrete. Subsequently other designers have followed the lead of these earlier designers with the result that almost all hydroelectric power plant superstructures are constructed of reinforced concrete without much consideration being given to the excellent results that can be obtained by using other forms of construction combined with a variety of choices of new materials.

It is the purpose of this article to present a design of a hydroelectric power plant superstructure using a light permanent welded steel rigid frame instead of the traditional heavy reinforced concrete construction now in use. It will further be shown that by comparison with present methods of construction in reinforced concrete, a welded structural steel rigid frame construction will result in a monetary savings and will allow faster construction, better use of natural light and heat, more efficient handling of heavy machinery and equipment and earlier installation of revenue producing generators and turbines.

Here a typical plant being constructed in the usual manner has been redesigned with a welded steel frame. The plans for the original structure are shown in Fig 1 and the suggested design is shown in Fig 2. The plant in Fig 1 has been in the design stage for a number of years, was redesigned in the period specified for this contest and bids were accepted on the structure recently. We have redesigned the structure within the specified period with the thought in mind that our design does not apply only to this structure but to all structures of this type and we have chosen this particular structure to redesign since it falls within the rules laid down and is not connected with a large dam but is a "run of the river" plant. The plant chosen houses three units and has a total capacity of 50,000 kw.

The advantages of using welded steel rigid frame construction over the conventional reinforced concrete frame construction in the design and construction of superstructures for hydroelectric power plants may be summarized as follows:

1. An estimated savings in initial cost of approximately $97,000.

2. An estimated increase in gross revenue, by being able to put the generating units in operation sooner, of $324,000.

3. An estimated savings in amortization of the investment over a 50-year period at 3 per cent of approximately $3755 annually by virtue of the reduction of cost and of approximately $11,426 annually by virtue of increase in revenue.

4. An estimated overall savings for the total repayment period of approximately $760,000.

5. Provides more healthful and pleasant working conditions by using natural light and heat at a savings in operation costs.

6. Provides a more efficient design by utilizing a more logical method for handling heavy equipment.

Description of Suggested Design

Present day hydroelectric power plant design usually calls for a superstructure of reinforced concrete in which the house crane is supported on a heavy crane beam carried on individual columns. Because the building columns are called upon to support the crane, resist crane thrust and act as the building column, the resulting column design is extremely heavy. The reinforced concrete walls are also limited in thickness by limits imposed in placing concrete in the form work. To avoid the limitations inherent in this design we have turned to welded steel construction. In our design, the superstructure acts merely as a protection or housing for the machinery and is not required to support the crane. The superstructure frame consists of a series of welded steel rigid frames, covered with a wall and roof materials of steel, asbestos, or other appropriate materials. The welded steel frames for ease of transportation could be delivered in conveniently sized sections which would be welded into a continuous rigid steel frame in the field. Any number of light modern materials could be used as wall surface, thus leaving the designer an unlimited choice. This type of design will produce a light permanent structure having none of the limitations of the reinforced concrete design at a considerable savings in cost.

In this design the heavy house crane is replaced by a gantry crane. In this way the crane load is removed from the building columns to the heavy structure. With the light steel frame construction size, hangar type doors would be easily installed in the end of the building to allow for the

This article by Owen Aftreth and Anthony Perry was presented originally as one of the prize winning papers in 1947 James F. Lincoln Welding Foundation Arc Welding competition. Both of the authors were formerly in the Design Office of the Bureau of Reclamation at Denver, Colorado. Mr. Perry is still with the Bureau but in the Washington office while Mr. Aftreth is with Wyatt C. Hedrick, Inc., at Fort Worth, Texas. Their paper should be of unusual interest to hydroelectric power engineers because the method of construction they describe breaks away from the traditional concrete design and with a considerable saving in cost. As compared with a concrete plant costing $303,675, the steel constructed plant they propose would cost only $207,050, a saving of over $96,000. The steel type of construction also has other advantages over the concrete design; it permits the use of better natural lighting and heating, and by the use of a gantry crane instead of the usual overhead house crane more headroom is obtained

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passage of the crane. The crane can be used both in and out of the building. In addition the crane can be installed in advance of the construction of the superstructure. In this way installation of the generating units can begin as soon as the substructure is ready. When the reinforced concrete superstructure is used, the installation of the machinery must be delayed until the superstructure concrete is complete and in condition to support the crane. The use of the welded steel frame also allows for installation of a wide expanse of glass surface to be incorporated into the design. Combined with proper louver design, great advantages in the use of natural light and heat can be accomplished. The louvers would be of steel welded in place to the frame of the building at the proper angle to cut out the vertical rays of the sun in the summer and at the same time allow for maximum use of the horizontal rays of the sun in the winter.

Savings in Cost Realized

In the Table II is a comparison of estimated cost between the Welded Steel and reinforced concrete superstructures. Only those items that are affected by the change in design are included in the comparative estimate.

The unit prices in the above tabulation are based on recent bids on this type of work. The unit prices shown include labor and material and are for the work completed and in place. For example, recent bids on placing reinforced concrete for a superstructure of this size ranged from $77 to $90. The cost of the material must be added to this price to obtain the total unit cost. For this comparison therefore we have assumed an average of $90 per cu yd for the work installed. Recent bids on steel have indicated an installation price of $0.10 per lb and prices quoted on steel shapes in the Engineering News Record for the locality where the plant would be constructed is $0.05 per lb. On reinforcing steel the installation price in recent bids is $0.06 per lb with quoted prices for material of $0.04 per lb. The large window openings in the original plant are of glass blocks. In our design glass block could be used or a more appropriate material would be the same and is based on recent bids on such material. Our design contemplates the use of aeroplane hangar type doors and for the purposes of comparison the unit price was based on unit prices of recent bids for large doors. The crane prices per pound are assumed to be equal but the gantry crane would of course be heavier than the overhead crane. However, with the overhead crane arrangement a transfer car is required to move transformers whereas in our design this function is performed by the gantry crane. While any number of types of wall material may be used to cover the steel frame which provides great flexibility of design, however, it seems that for general purposes an insulated steel plate or insulated corrugated steel would provide the most efficient and functional covering. This is the type of material which was chosen for estimating purposes. Roof decks would be of steel covered with the usual roofing materials. It is contemplated that both the steel deck and the wall covering materials would be spot welded to the steel frame in place of using connectors in order to reduce weight.

Total Cost Savings

The estimated cost savings shown in Table II of paragraph 6 represents only a savings in first cost. However, the actual savings would be greater since the practice is to finance the investment over a period of years. Any savings in first cost automatically results in a savings in interest required to be paid on the investment. If we assume that the investment must be ammortized over a period of 50-years at 3 per cent interest, then by reducing the initial investment by $96,625 as shown in Table II the annual payment at 3 per cent for a period of 50-years is reduced $3755. The total reduction for the period is $188,750 and the interest saved over the period is $92,125. In addition to the above savings additional revenue can be made available by employing the design suggested in this paper. The installation of the units can be scheduled to start as soon as the substructure is ready to receive them. There would be no delay while waiting for the reinforced concrete superstructure to be placed and for the concrete to cure and strengthen. The result would be that the generating units would be ready to deliver power at least three months earlier than if the plant is constructed in the usual manner. If

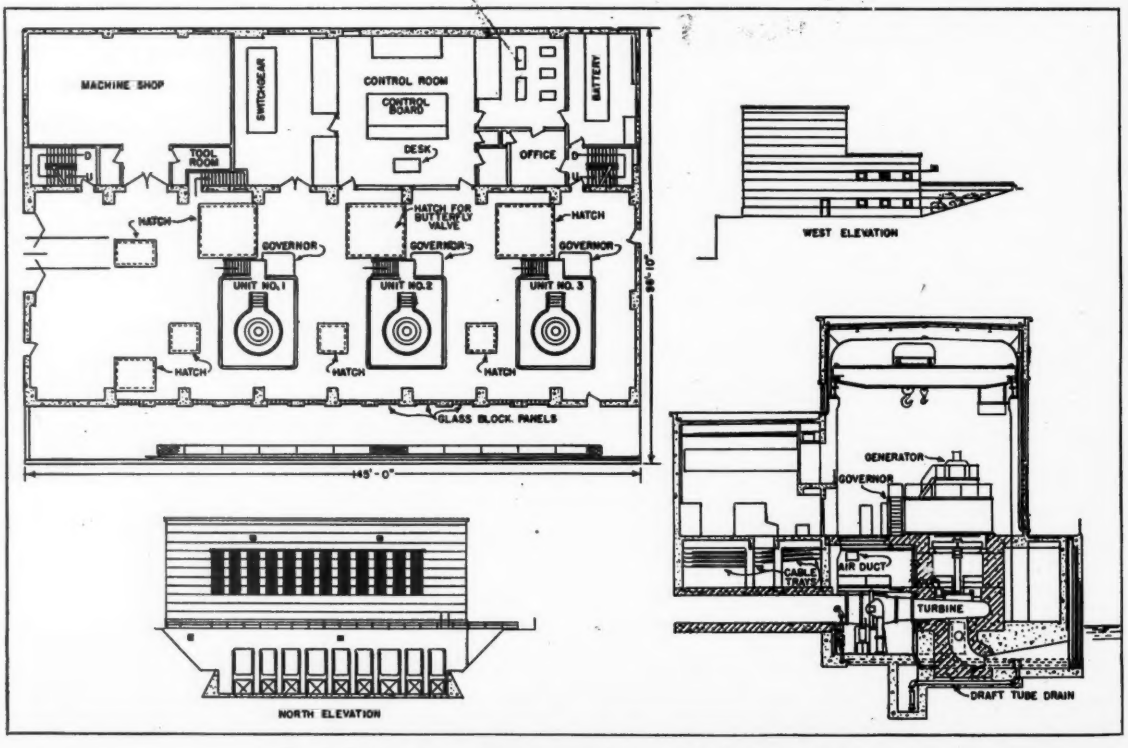
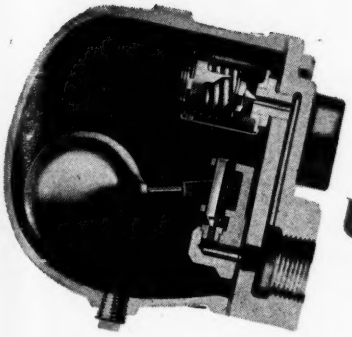


Fig. 1. Details of the 50,000 kw concrete type of hydroelectric plant



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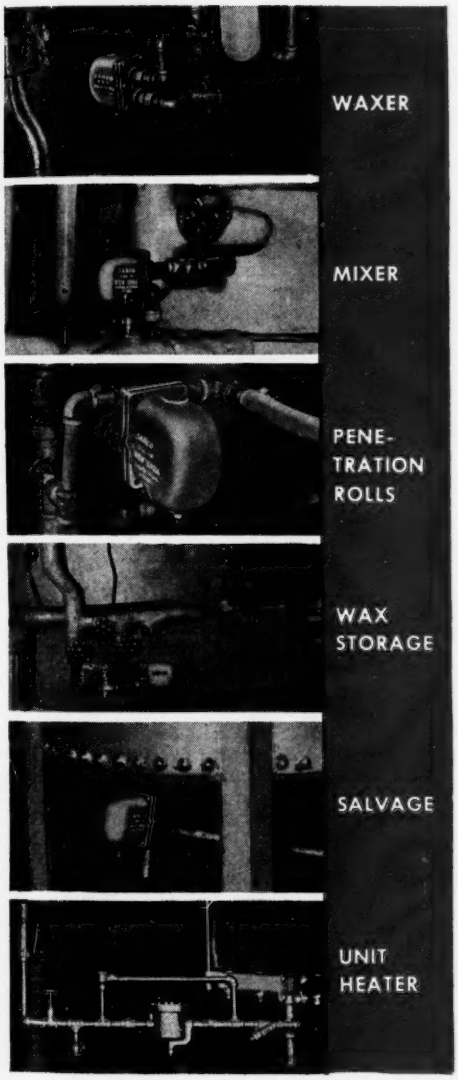

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we assume a 50-per cent load factor the total energy generated over the three month period from the three machines with a total of 50,000 kw would be approximately 54,000 kw-hr. At an average rate of 6 mils, the gross revenue gain would be $324,000. After deducting operating, maintenance and replacement charges the net revenue of $294,000 when applied to the investment would have an effect of saving annually over a 50-year period at 3 per cent, $11,426 or a total over the 50-year period of $571,300. The total savings resulting from the adoption of the welded steel rigid frame construction is as follows:

Table I showing total savings

In initial cost	$ 96,625
In interest payments	92,125
In effect of additional revenue	571,300
Total Savings	$760,050

Advantages in Heating and Lighting

The adoption of this design of welded steel permits the designer to take advantage in his design of natural heating and lighting which would eventually lead to savings in the operation and maintenance of the power plant. Since the actual amount saved by incorporating these features in the design vary with the location of the plant, no attempt has been made to compute the advantages in dollars and cents. The steel louvers shown in Fig 2 would be welded to the steel frame at the proper angle depending on the orientation of the plant and its location. The purpose of the louvers is to cut out the direct rays of the sun during the summer and allow the horizontal rays to enter during the winter thus saving energy which could be sold. During the summer one of the largest loads on the air conditioning system is contributed by solar heat. This load could be practically eliminated by proper shading which would be provided by the steel louvers as described above. In South American countries this method is used extensively in building construction and in some cases constitutes all the air conditioning that is required. The uninterrupted expanse of glass extending across the entire walls is more adaptable to the steel frame construction suggested in this paper since large thick members required in conventional designs have been eliminated. By properly deflecting the rays of the sun by use of the louvers, glaring light is eliminated and a more healthful and pleasing working space is provided.

Table II. Comparison of estimated costs reinforced concrete superstructure

Items	Quantity	Unit	Initial Price	Amount
Superstructure Concrete	2,000	C.Y.	$ 90.	$180,000
Reinforcing Steel	300,000	lbs.	0.10	30,000
Roof Steel	200,000	lbs.	0.15	30,000
Windows (Glass Block)	2,000	S.F.	3.50	7,000
Doors	500	S.F.	1.75	875
Transfer Car	1	@	2500.00	2,500
80-ton Overhead Crane	133,000	lbs.	0.35	46,550
Concrete Form Lining	45,000	S.F.	0.15	6,750
				$303,675

Welded Steel Frame

Item	Quantity	Unit	Initial Price	Amount
Welded Steel Framing	600,000	lbs.	0.15	$90,000
Roof Deck Material	12,500	S.F.	0.50	6,250
Wall Material	17,000	S.F.	1.00	17,000
Windows	7,500	S.F.	3.50	26,250
Doors	2,600	S.F.	1.75	4,550
80-ton Gantry Crane	180,000	lbs.	0.35	63,000
				$207,050

Estimated Savings in Cost = $96,625

Advantages in Equipment Handling

By using a gantry crane instead of the usual overhead house crane, distinct advantages can be gained in the handling of equipment. When using the overhead crane, provision must be made for clearance at the ends of the building with the result that the crane hook cannot be brought to closer than from 7 to 10 ft of the building wall. In this way valuable handling space is wasted. The location of hatches in the generator floor must be restricted due to the limited handling space of the crane. In addition, space required for the erection of the units is also restricted. In the suggested design, where the crane is free to move in and out of the building these restrictions are eliminated. Under favorable weather conditions work can be done in the open. The handling of transformers is greatly facilitated since the same crane can pick up the transformer at the switchyard and carry it into the power plant for untanking purposes. The present method requires several handlings in which a transformer car on a separate track is used. This is an awkward method of handling this piece of equipment which is eliminated in the suggested design. Also the use of the gantry crane would greatly facilitate the loading and unloading of heavy equipment from trucks and trailers. No monetary value can be placed on this method of handling equipment, but the added efficiency of handling heavy equipment cannot help but pay off in the day to day operation of the plant.

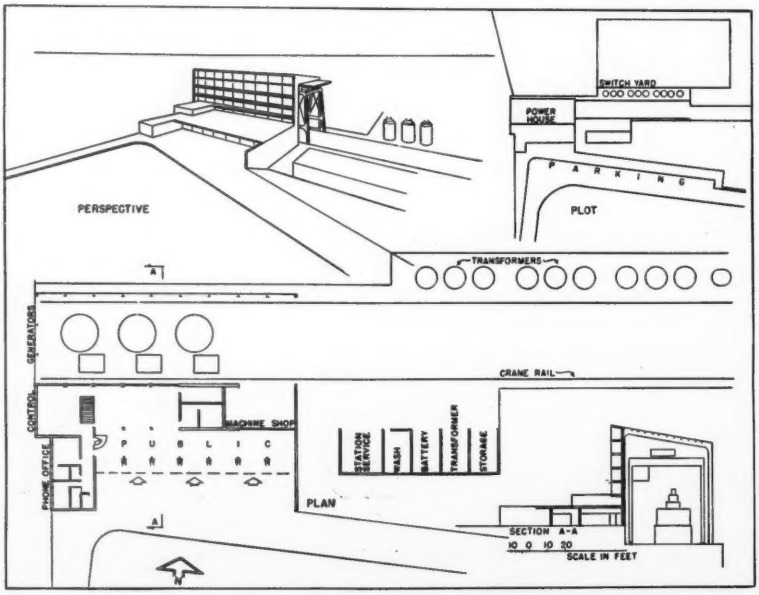

Fig. 2. Details of the proposed welded steel frame type of plant

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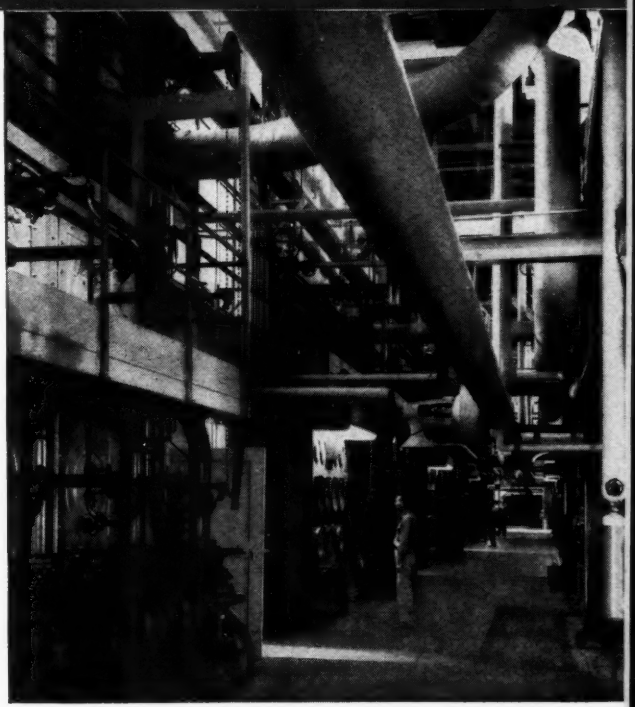

Figure it in dollars and cents: How much power are you losing due to accumulations of scale and sludge in boilers, condensers and other heat-exchange equipment? How much is it costing you for the extra fuel required to overcome the reduced efficiency imposed on your plant by *insulating deposits?*

Take a good look at your designed operating efficiency—and compare it with the *actual output* you are securing. Then call the nearest Dowell office for the facts and figures on *chemical* scale removal service.

Leading plants everywhere rely upon Dowell service—including some of the largest boiler installations in the nation. They tried Dowell service and found it rapid, safe and economical. They've seen Dowell engineers fill plant equipment with liquid solvents designed to dissolve and disintegrate scale and sludge—and they've seen the *results.* You'll make no mistake to follow their example—get the facts.

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Boiler Feed Pump Corrosion?—Here's What You Can Do About It

By H. L. ROSS, *Chief Engineer, Centrifugal Pump Department, Allis-Chalmers Manufacturing Co.*

Maintenance problems in high-pressure boiler feed pumps . . . Causes of corrosion-erosion partly chemical, partly mechanical . . . Influence of feedwater pH value, water velocities, quality of workmanship . . . Remedies in existing carbon-steel pumps are proper feedwater treatment and recirculation . . . Repair steel casings by welding in stainless steel or building up low-temperature brazing alloy . . . How 18-8 stainless steel liner is welded in; must be done at factory; costly; helps keep pump going . . . Use of protective coatings often successful . . . When corrosion-erosion of detail parts occurs, cheaper to replace with proper materials . . . For new installations, avoid carbon steel and select pumps of corrosion-resisting materials now available

REFINEMENTS in feedwater treatment have introduced many problems in boiler feed pump maintenance, particularly in pumps which were constructed with carbon steel parts. For many years, carbon steel was a standard material for boiler feed pump casings, diffusers and other parts, and it worked fairly well. Then refinements in feedwater treatment led to lower pH values and lower solids content and then carbon steel parts gave trouble.

Generally, this trouble manifests itself in cutting across joints between stages, erosion of volutes and diffusers and occasionally cutting underneath the impeller and attacking the shaft. Until rather recently no co-ordinated effort was made to study causes of this corrosion-erosion, but sufficient data are now available to point out the causes of this trouble, and to permit steps to be taken to avoid it in the future.

Causes of Corrosion-Erosion

Corrosion-erosion is caused by a combination of chemical and physical attack. Although the exact causes of this attack are not known, the following seem to be the most significant:

pH Value:—The pH value seems to be the most significant of the feedwater properties that have been investigated. In general, a feedwater with low pH value spells trouble for any parts of carbon steel. However, with a pH value of better than 9.0, there is a good chance that carbon steel will be satisfactory.

Temperature:—Effect of temperature on the corrosiveness of the water is not definitely known, except that it would seem that higher temperature waters are likely to cause more trouble. This is probably because the pH value of water decreases with an increase in temperature and, of course, actual pH measurements are made at near room temperature.

Mechanical Causes:—Corrosive action of the water is definitely mechanical as well as chemical; because, even when handling a water known to be corrosive, the passages in which the water velocities are low are either unattacked or only slightly attacked. On the other hand, points where the velocities are high are not attacked when the water is non-corrosive or when the material is resistant to the water.

It is, of course, impossible to build a boiler feed pump with velocities low enough through the impellers and volutes to avoid attack at these parts if the water is corrosive to the material. The high velocity breaks down the protective film formed over the metal. It is quite definite that the attack is a combination of chemical and mechanical action.

Poor machine work contributes to the starting of trouble of this nature, because a poorly-machined fit between stages will have an initial leak, which will result in a high velocity across that portion and subsequent corrosion of the material. Hence good machine work is important. However, it is practically impossible to have machine work perfect enough so that no leakage whatever will occur. The only practical solution is to have materials that are resistant to the water so that a slight leakage results in no damage.

Remedies for Corrosion-Erosion

Either special water treatment or pump repairs or both must be resorted to in combating the effects of corrosion-erosion:

Feedwater Treatment:—Where carbon steel pumps are installed and it is necessary to continue them in service with a minimum of repairs, it is often expedient to increase the pH value of the water so that the pumps will not be attacked. This can be done by recirculating a small amount of boiler water back to the pump to raise the solids content and the pH value of the water to a point where attack will not occur. A recirculation of about 2 per cent of capacity is sufficient.

In connection with this, it is important that this recirculating line be brought back to the deaerator, as shown by solid line, Fig. 1, and **not** adjacent to the pump suction, as shown by dotted line. A serious pump failure can occur when this line recirculating high-temperature water is introduced close to the pump suction, because the water may immediately flash into steam, causing the pump to lose suction at light loads.

Another method of raising the pH value calls for the addition of sufficient sodium hydroxide to raise the pH value to about 9.5; this will generally stop any action on carbon steel parts. However, in this connection, it is well to watch the other parts of the pump carefully, for bronze is apt to be attacked at pH values in excess of 9.5, while a pump with either cast-iron or stainless-steel fittings will be

Although based on a paper delivered by the author before the 1947 Midwest Power Conference, this is a completely new article with new data and illustrations, written especially for the readers of POWER GENERATION.

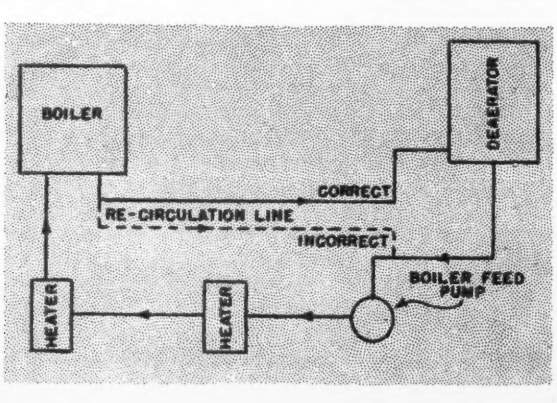

Fig. 1. When recirculating feedwater to raise pH value of water to prevent pump corrosion, be sure to recirculate it to deaerator (solid line) and not just ahead of pump (dotted line), where it might flash and cause pump to lose suction at light load

This RIC-WIL Insulated Steam Line Produced HIGHER End Pressures with LOWER Boiler Pressure . . . in AKRON

Increasing end pressures by 8 to 10 pounds in an underground steam distribution system while decreasing pressure by 25 pounds at the boiler plant may sound paradoxical . . . but that's just what the Ohio Edison Company accomplished in Akron.

The capacity of the system's main feeder, which carries 600 million pounds of steam annually to 422 customers, was being taxed severely to maintain required pressures at several end points during peak periods.

To solve this problem, Ohio Edison installed an additional feeder tieing into the system at a point 800 feet from the boiler plant. When it was cut into service, pressure at the boiler plant was reduced from 185 pounds to 160 pounds while end pressures increased 8 to 10 pounds.

As a result, the Company is able to offer service to additional customers in those areas. The "booster line" also assures uninterrupted service even when the main feeder from the boiler plant is cut out for inspection or repair. The installation has been so completely successful, an extension of the "booster line" is scheduled for construction during 1948.

Ric-wiL Pre-fabricated Insulated Pipe Units were specified for this job because of their high thermal efficiency and dependability . . . because they could be installed in shallow trenches with as little as 18 inches of cover . . . because several 21-foot units could be welded above ground and jacked under railroad tracks without interrupting train service . . . and because the ease of handling effected considerable savings in installation time and cost.

For more complete information on Ric-WiL Systems send for folder, Form 4708. Write Ric-wiL Dept. 782.

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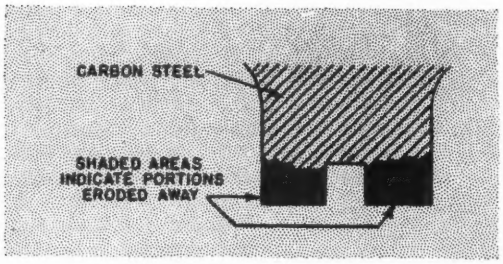

Fig. 2. How a steel pump casing is attacked by cutting across the fits. This is a section through the eroded fits shown in Fig. 3

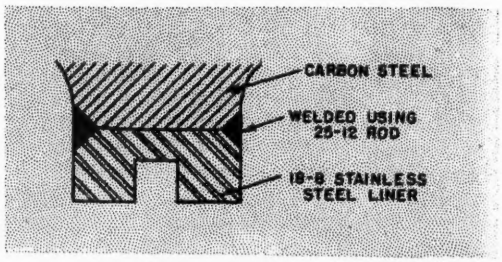

Fig. 4. Section through corroded pump fitted with stainless steel liner welded in and rebored. Actual pump appears in Fig. 5

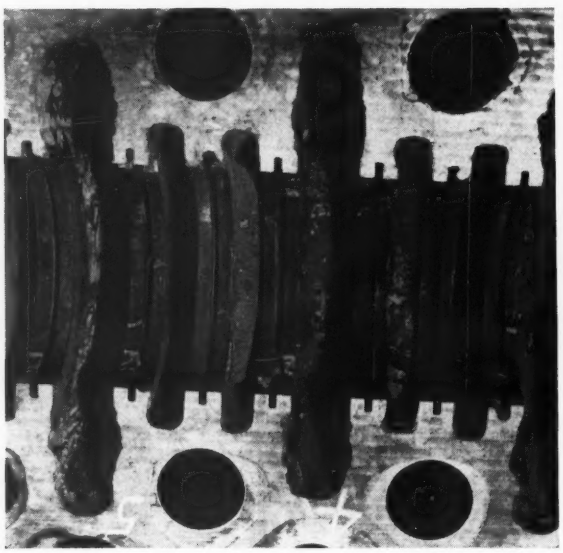

Fig. 3. Half casing of carbon steel, showing corrosion-erosion of fits and volutes. This casing was temporarily repaired by silver soldering and re-boring in the field

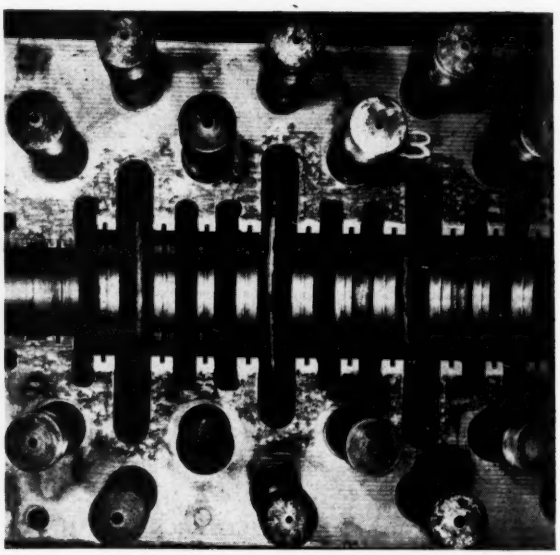

Fig. 5. View of carbon steel pump casing that was corroded-eroded and then repaired by welding in stainless steel liners and reboring

quite satisfactory in water of this pH value.

Pump Repairs:—When a steel casing is attacked by cutting across the fits as shown in Figs. 2 and 3, it is possible to build up these fits by welding in stainless steel. This is best done with a 25 chrome-12 nickel rod. On low-carbon steel this welding may be done cold, with no subsequent heat treatment required. Building up with a low-temperature brazing alloy is also a satisfactory method of repair, since the brazing material is generally quite resistant to the water which attacked the steel.

Such repair in the field is a very difficult matter under best conditions. Where extensive welding has to be done, the casing must be rebored. Difficult to do with a portable boring bar, it has been accomplished, nevertheless, in many instances. It is also quite possible that if any extensive welding is done on the casing, warpage of the casing will occur, making it necessary to reface the main joint and rebore the entire casing.

Welding in Stainless Steel

In welding in stainless steel at the interstage fits, it is necessary to clean out the erroded portions thoroughly and get the welds thoroughly bonded to the casing. If a leak should occur between the weld and the casing, it will cut out in back of the welds, and the repair work will have to be done all over again.

In a number of cases, an 18-8 stainless-steel liner has been welded into the original casing as shown in Figs. 4 and 5, and a very satisfactory repair has been made. However, this is a job that must be done at the factory, and it usually results in a cost in excess of the cost of the replacement of an entire casing. Furthermore, there is the possibility that corrosion-erosion will still occur at the junction of the stainless liner and the carbon steel, so that further repair work will have to be done. Therefore, it is an expedient to be resorted to only where the work must be done quickly, to avoid keeping the pump out of service too long.

How Protective Coatings Have Been Used

Some success in retarding the attack of feedwater on carbon steel has been achieved by using a protective coating, such as Apexior. Encouraging experimental results with a bakelite lacquer (known as BL3128, manufactured by the Union Carbide & Carbon Co.) are also reported. This material is applied after thoroughly sand-blasting the base material then baking the coating at about 350 F. Only 0.0003 in. thick, the coating on an experimental sample was unattacked after a 500-hr accelerated test. While there might be some difficulty in keeping it from chipping at machine joints, yet it is certainly worth trying where feedwater pumps are giving trouble. Reports of its performance will be looked forward to with interest.

Repair of Detail Parts

When trouble from corrosion-erosion on detail parts occurs, it is usually cheaper and better to replace the parts with materials resistant to the feedwater rather than to attempt anything more than a most temporary repair.

The parts for the rotor must be selected with great care, since many considerations are involved in their selection. For smaller pumps of lower pressures, where the pH value does not exceed 9.5, bronze is generally a

ENGINEERING PROGRESS REPORT #18

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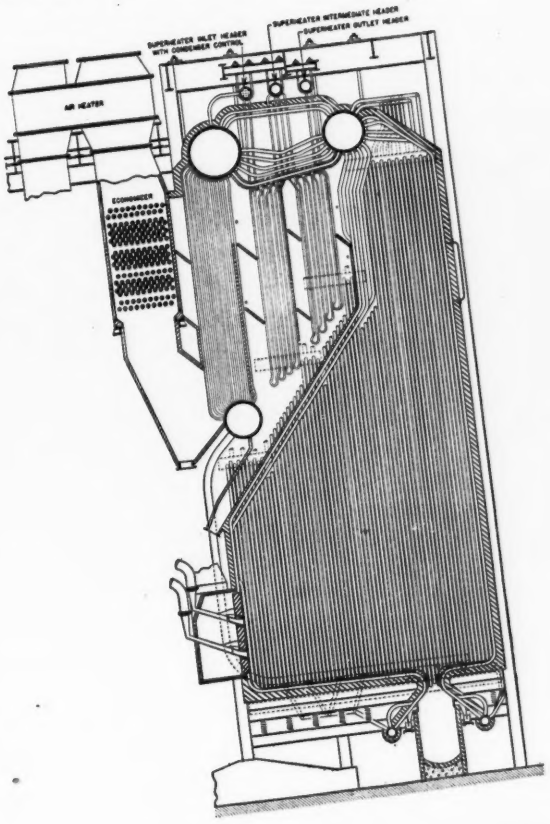
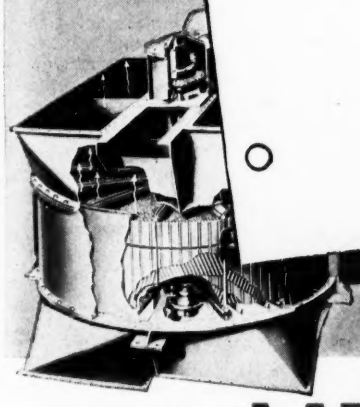


Here is another application of a Ljungstrom Air Preheater to a Foster Wheeler boiler.



THE

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very satisfactory material. It has the advantage of low cost, freedom from galling and good corrosion resistance, with perhaps the only disadvantage of a rather high coefficient of expansion.

For smaller pumps where the pH value is in excess of 9.5, cast-iron parts are, in general, quite satisfactory. However, for large pumps at high pressures, where the velocities are high and where the water conditions are such as to keep the pH value and the solid content at a minimum, stainless steel fittings are definitely recommended because they are practically immune to any attack.

For impellers either monel or stainless steel are practically immune to attack. Monel is an easier material to cast, and we have no reported cases of failure of this material in any feedwater.

In selecting wearing rings, it is important that a material be selected which will not gall readily. Materials of the 12-14 chrome-stainless group are satisfactory when heat-treated to provide a good differential of hardness. For instance, a casing wearing ring at 500 Brinell will run satisfactorily with a 350 Brinell impeller wearing ring.

For shaft sleeves, even on low pressure pumps, it is desirable to use a stainless steel of the 12-14 chrome group, hardened to about 450 Brinell. Some trouble has been reported with sleeves heat-treated to 500 Brinell or harder, because the material is rather brittle and subject to cracking.

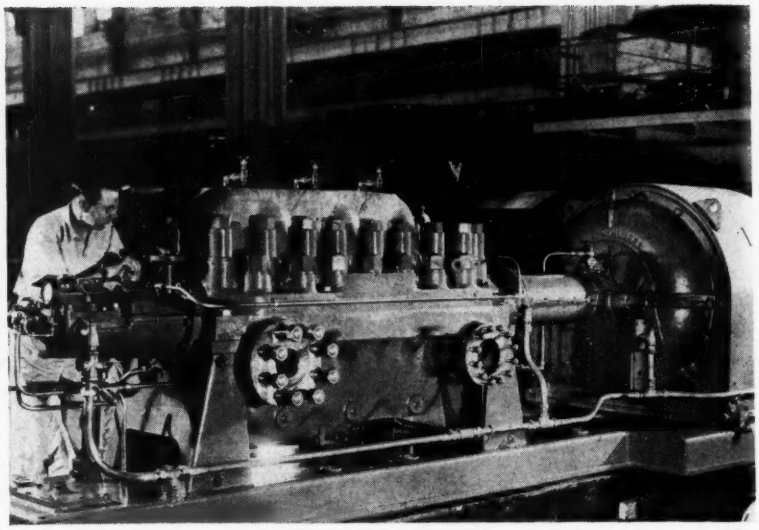


Fig. 6. Shop view of a modern motor-driven high-pressure boiler feed pump

Stellite sleeves are also quite satisfactory. However, they are expensive and some failures have been reported due to the cracking away from the metal underneath.

New Pumps Can Have Proper Materials

The above comments on casing material generally refer to casings which are already in operation with suggestions for their repair. For new installations, carbon steel casings are definitely not recommended under any conditions. Cast iron has been satisfactory on lower pressure pumps, and a 4-6 per cent chrome-steel has been entirely satisfactory and no failures have been reported to date. However, it is difficult to weld in the field, and for this reason many pump users have been specifying 18-8 materials. Although more expensive, they are even more resistant to corrosion and are readily repaired in the field by welding.

There is reasonable assurance that on properly-engineered new pumps, manufacturers can now select materials that will assure freedom from trouble.

HIGH-TEMPERATURE ALLOYS

By W. C. LESLIE and D. J. McPHERSON[1]

Research Associates,
Engineering Experiment Station
The Ohio State University

IN RECENT YEARS, great strides have been taken, particularly as an outgrowth of organized wartime research, in the development of superior alloys to meet the demands of service at continuously increasing high temperatures. Prior to the demand for heat-resisting metals for use in gas turbines, most of the work on this type of material was done at the behest of the oil and power industries.

Several of the alloys which are being applied in high-temperature work were originally developed prior to the war as corrosion-resisting materials. Vitallium (62 per cent Co, 28 per cent Cr, 5½ per cent Mo) was introduced in 1934, when a patent was granted for use as an investment-casting material for dentures. With a reduced carbon content, Vitallium now is being used for cast gas turbine buckets.

Inconel (80 per cent Ni, 14 per cent Cr, 5 per cent Fe) was developed primarily for use in the food industry where its freedom from tarnishing and other effects of corrosion were of great advantage. The Hastelloys (A, B, C, and D) were developed to resist corrosion, particularly by hydrochloric acid.

With the beginning of World War II, it was realized that much research had to be undertaken to test known alloys and to develop new heat-resisting alloys for use in gas turbine parts. Under the sponsorship of the OSRD and the NACA, practically all the high-temperature testing facilities of the nation were employed. Alloys were tested through the temperature range 1200-2000F.

Largely as a result of this research, operation temperatures have risen from 1000 to almost 1500F. The easy advances appear to have been made and further gains will be slow and difficult.

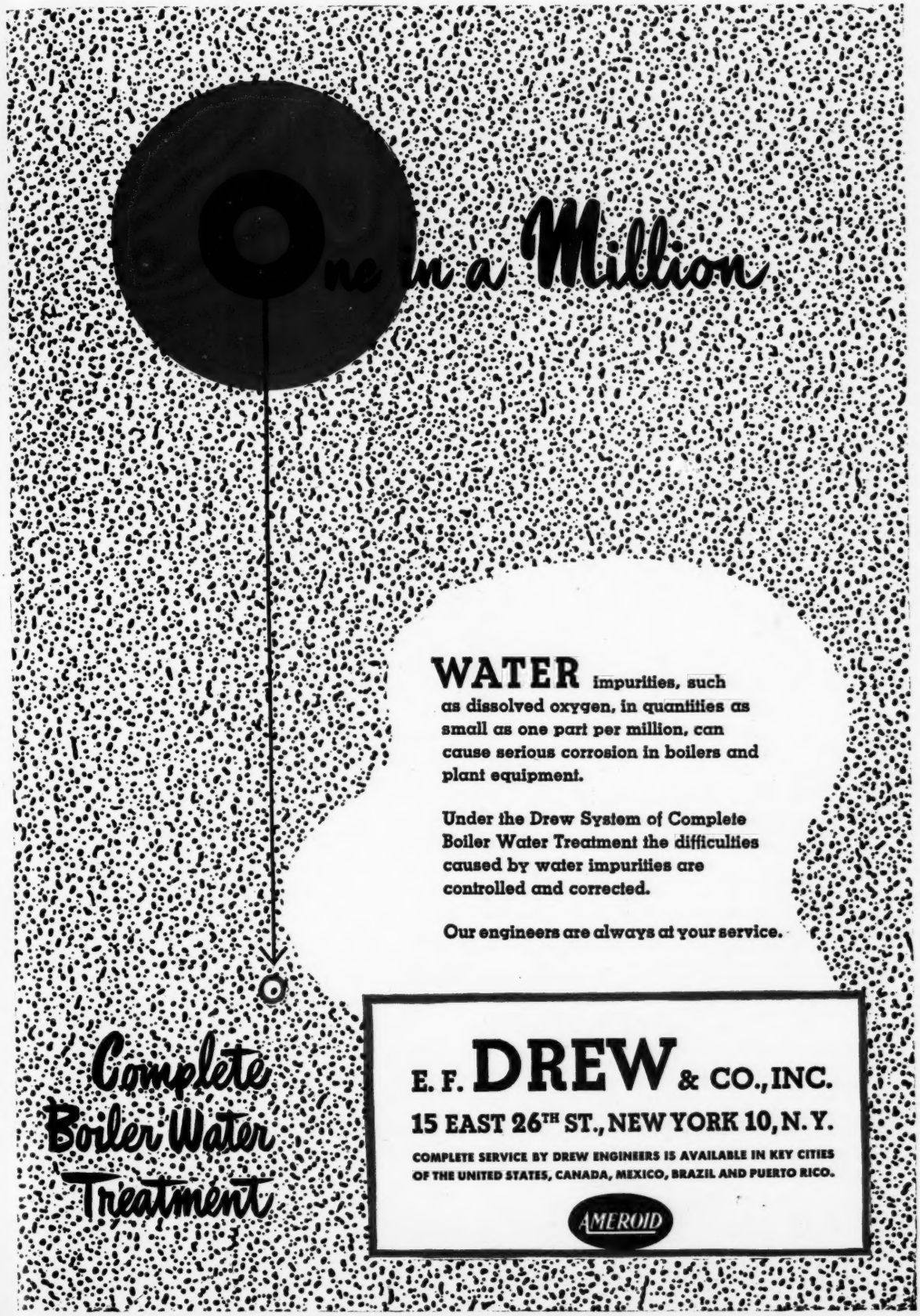
Work is being done in this field at The Ohio State University through sponsored projects as reported in its *Engineering Experiment Station News*. The two investigations to be described in this report are a study of Timken 16-25-6 alloy and an investigation and evaluation of chromium-titanium binary alloys.

Timken 16-25-6 was developed as a high-temperature alloy by the Timken Roller Bearing Co., the work beginning in 1940. It was desired to obtain an austenitic alloy with about 50 per cent iron, no strategic alloying materials, very good high-temperature strength, good forgeability and machinability and high oxidation and corrosion resistance. Chromium was included in the alloy because of its effect on oxidation resistance and molybdenum was added to impart high-temperature strength. Sufficient nickel was included to balance the chromium and molybdenum and to keep the austenitic. Timken 16-25-6 was first used in the manufacture of turbosupercharger rotors and later for the rotors of aircraft turbojet engines. It is produced commercially in 25-ton electric furnaces and cast into 14 to 21-inch round corrugated ingots.

The metal chromium is an important constituent of nearly all of the refractory alloys described above, because it imparts high-temperature oxidation resistance.

Titanium is one of the lightest (sp. gr. 4.5) of the fairly plentiful high-melting metals. The elements chromium and titanium may conceivably benefit each other to the extent that a series of useful alloys may be obtained throughout the whole range of the binary system.

[1] This paper includes reports of work carried out under Research Foundation Projects No. 297 and No. 298, Air Materiel Command, Wright Field, Dayton, Ohio.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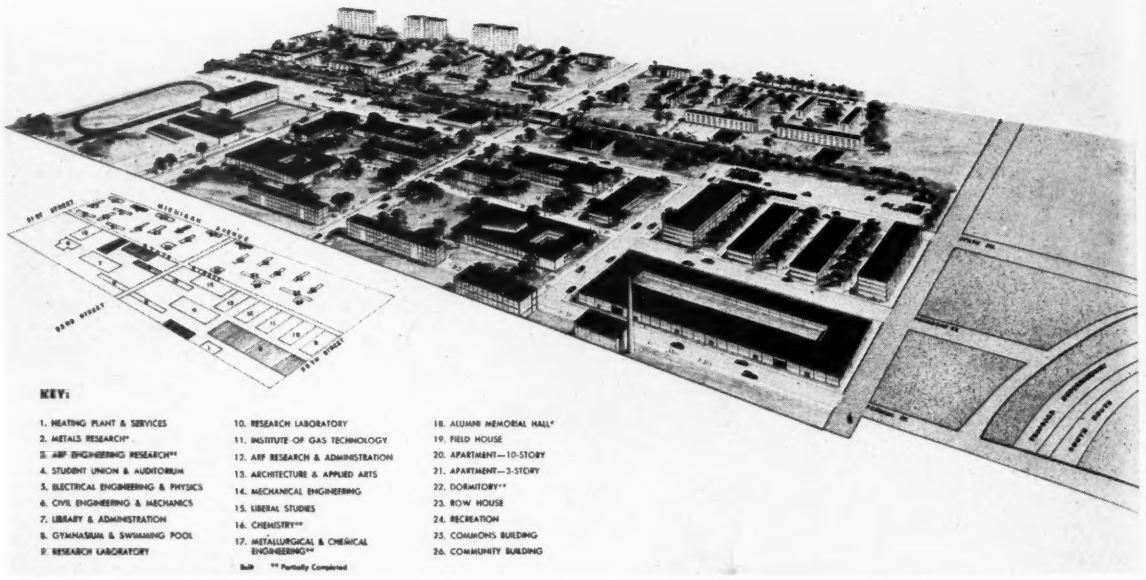


THE WORLD'S most modern college campus is growing out of one of the nation's worst blighted areas under the impetus of a $15,000,000 development and expansion program of Illinois Institute of Technology which is transforming its Technology Center campus into a functionally planned study and residential area for 10,000 persons.

Covering the 100 acres, eight minutes south of Chicago's loop, from 31st to 35th streets, and from Michigan Ave., to the New York Central railroad tracks on the west, the campus area being rebuilt represents one of the rare instances in modern times where it has been possible to design a group plan on so large a scale.

Architecture for the campus was created by Ludwig Mies van der Rohe, a foremost exponent of modern architecture and chairman of the department of architecture at Illinois Tech. Academic and laboratory buildings incorporate extensive use of glass for abundant light. The outstanding feature of the type of architecture itself is its striking simplicity.

Development Program to Be Complete by 1953

With the program already underway, three new buildings have been erected at Technology Center and are now in use. These are a Metals Research building erected in 1943; a wing of the Engineering Research building, 1945; and Alumni Memorial Hall, 1946.

Being completed now is a new Chemistry building and a Metallurgical and Chemical Engineering building. Under construction also are two four-story student dormitories, as part of the Institute's plan to house 2,000 students, staff, and families in permanent apartment, residence, and dormitory dwellings adjacent to the campus.

Besides these buildings, 59 additional academic, laboratory, campus, and housing structures will be erected over a five-year period, Henry T. Heald, Illinois Tech president, announced recently.

Scheduled for construction are the following buildings: Liberal Studies, Heating Plant and Services, Library and Administration, Institute of Gas Technology, Mechanical Engineering, Civil Engineering and Mechanics, Electrical Engineering and Physics, and Architecture and Applied Arts.

Also to be erected will be two research laboratories for the Institute's Armour Research Foundation, a Student Union and Auditorium, a Gymnasium and Swimming Pool, and a Field House.

A component of the over-all development program is a complete housing plan which will make the campus a cohesive study-work-and-living unit.

Housing Plan

Three 10-story elevator apartment buildings for the staff and married students will be built on the west side of Michigan Ave. between 31st and 33rd streets. Behind these elevator apartments, three 3-story walk-up apartment buildings for additional staff and married students will be erected. Ten more 4-story student dormitories are to be built supplementing the two already under construction. Twenty-four Row Houses for faculty members and their families are planned, as well as a Commons building with complete dining facilities, and a Community building with shopping, clubhouse and recreational facilities.

"When Technology Center of Tomorrow is completed, it will most certainly be one of the nation's most modern centers of technological education and research," James D. Cunningham, chairman of the Board of Trustees, asserted.

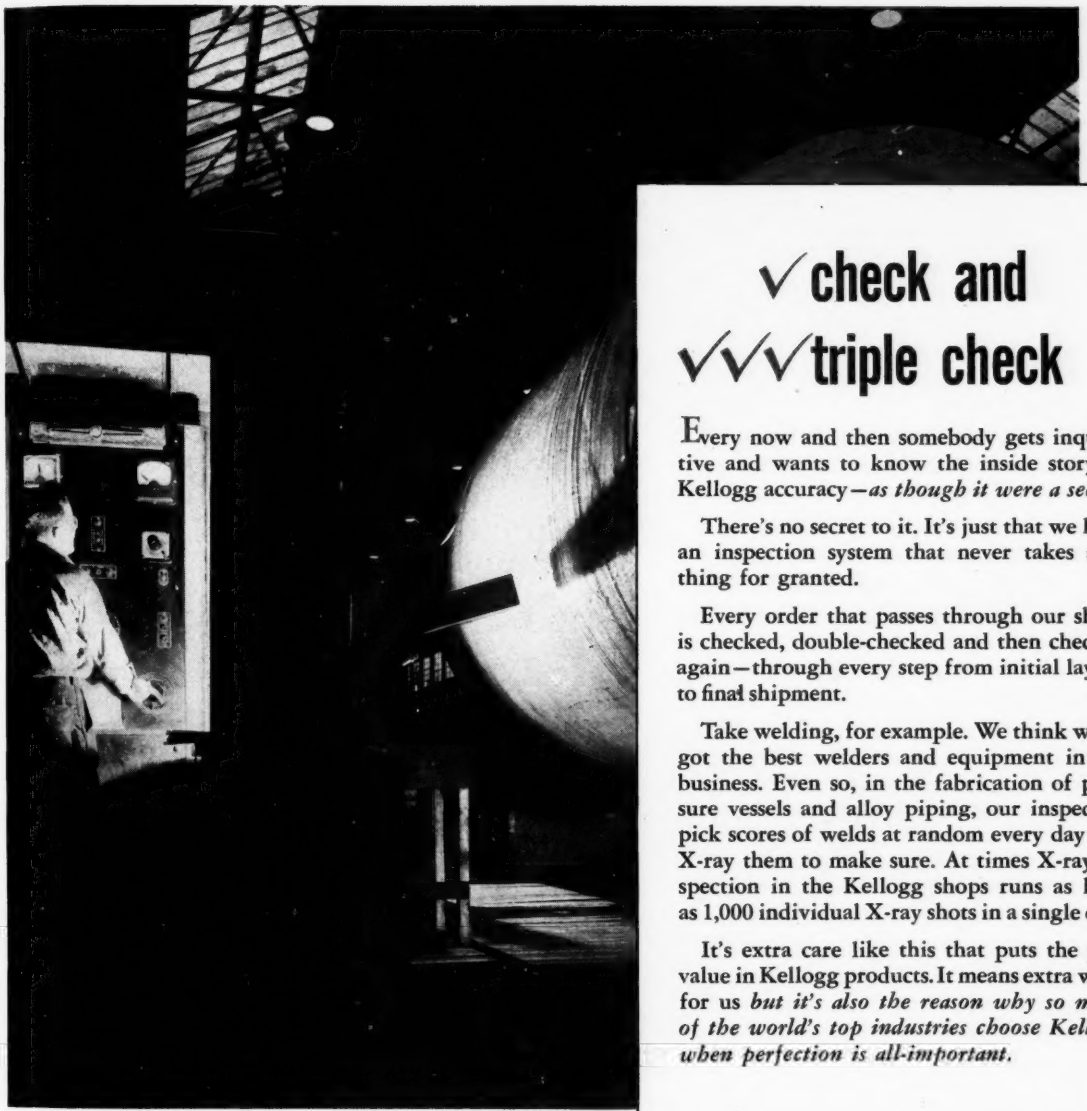
The rebuilding program will eventually replace the 50-year-old academic and laboratory buildings which the college has been using since it was founded in 1892 by Philip D. Armour as Armour Institute of Technology. Illinois Tech is a result of the merger in 1940 of Armour Institute and Lewis Institute, founded in 1896 by Allen C. Lewis.

Illinois Tech Has Grown Rapidly

Since 1940 it has grown phenomenally and far outstripped its physical facilities. Its volume of research has increased 12 times since 1940. At that time fundamental and applied research totaled $251,846. Today it has exceeded $3,356,000. Enrollment is up 63 per cent over the 1940 total of 5,148. The 1947-48 enrollment is 8,400.

Assets of Illinois Tech have increased 120 per cent from the 1940 total of $5,097,638 to a 1947 aggregate of $11,218,484. Additions to the staff and faculty have been made constantly since 1940, at which time 360 persons taught or worked at Technology Center. The comparable 1947 figure has now reached 1,300 persons.

Annual income has increased 292 per cent. In 1940 income was $1,707,618, and today it totals $6,697,900. Land owned has also kept pace with this constant growth. Today the college owns 9 times its 1940 acreage. At that time it possessed 7 acres; its 1947 campus land holdings now total 65 acres.



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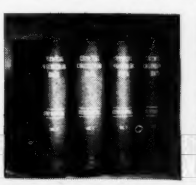
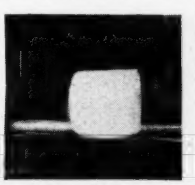


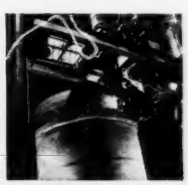
Unique Technical Backing of an extensive organization with an international reputation in both process and fabrication engineering.



Complete Facilities for the fabrication of steel products from simple forgings to the most intricate 120 foot towers.

Quality Control embracing the constant application of the most advanced inspection methods, both visual and non-destructive.

On-Time Delivery made possible by a flexible planning group authorized to re-route work to meet promised dates.



Top Welding Performance assured by specially designed equipment and exclusive employment of master operators.

BY "heat" we mean anything to 1600°F., for steel-industry use on all types of furnaces and stacks has proved THUR-MA-LOX Number 7 surfacing effective over that range of metal temperature.

Yet THUR-MA-LOX, unlike many heat-resistant coatings, protects at low temperatures, too, just as it does at high.

For instance, a THUR-MA-LOX-coated stack may be taken out of service at red heat and allowed to cool in sub-zero winter cold with no effect whatever on its corrosion-resistant qualities. Or it may be allowed to stand for an indefinite time after coating before being subjected to high heat, or even to any temperature above atmospheric.

The reason is that the protecting pigments of THUR-MA-LOX are sealed to metal not by one vehicle, but by two. The first is effective at low temperatures before high heat; the second takes over for upper-bracket readings and stays on the job for any subsequent dips to lower temperatures.

Together they make a good team — one you can really count on for the type of application where everything else has failed.

THUR-MA-LOX Number 7 is black—weather-resistant—effective to 1600°F. Its companion coating, THUR-MA-LOX Number 10 Aluminum will give you the same long-lasting protection in sheltered locations to 1200°F.

DAMPNEY maintenance for metal

THE DAMPNEY COMPANY of AMERICA • Hyde Park, Boston 36, Mass.

COMING EVENTS

ASME—Spring Meeting of the American Society of Mechanical Engineers to be held at New Orleans, La., March 1-4, with headquarters at the St. Charles Hotel.

Stoker — Chicago Stoker Exposition; to be held in Chicago, March 11 to 17, inclusive, at the Commonwealth Edison Assembly Hall.

Chicago Technical Conference — To be held March 22 to 24 in conjunction with the annual Chicago Production Show, at the Stevens Hotel.

EEI—The 14th Annual Conference of the Edison Electric Institute will be held at the Edgewater Beach Hotel, Chicago, April 6-8.

Midwest Power Conference—Tenth annual Midwest Power Conference; to be held in Chicago April 7, 8 and 9, at the Sheraton Hotel (formerly the Continental Hotel).

ASCE—1948 Spring Meeting of the American Society of Civil Engineers to be held in the William Penn Hotel, Pittsburgh, April 7-9.

Refrigeration — Second annual Western Refrigeration Educational Exhibit and Conference; to be held in San Francisco April 30, May 1 and 2, at the Palace Hotel.

Surface Reactions—The Pittsburgh International Conference on Surface Reactions will be held at the Mellon Institute for Industrial Research in Pittsburgh, June 7-11.

Instrument Society—Instrument Society of America annual meeting to be held in Convention Hall, Philadelphia, September 13-17.

NATIONAL ELECTRONICS CONFERENCE

THE NATIONAL ELECTRONICS CONFERENCE, INC., a non-profit organization serving as a national forum for the presentation of authoritative technical papers on electronic research, development and application, held its annual meeting at the Edgewater Beach Hotel, Chicago, on November 3, 4, and 5, 1947. The total registration was 2475, exclusive of 550 courtesy admissions to the exhibits only. There were 20 technical sessions at which a total of 78 technical papers were presented.

NEW TURBINE FOR ESSEX

A NEW 100,000 kw turbine generator was placed in service recently by Public Service Electric and Gas Co. at its Essex Electric generating station in Newark. This increases the total electric generating capacity of the Public Service system to 1,211,150 kw which is more than 100,000 kw in excess of the record peak demand to date.

In anticipation of future demands for electric power, Public Service is erecting a new 300,000 kw electric generating station at Sewaren, two units of which are scheduled to be placed in service next fall and the third unit in the fall of 1949.

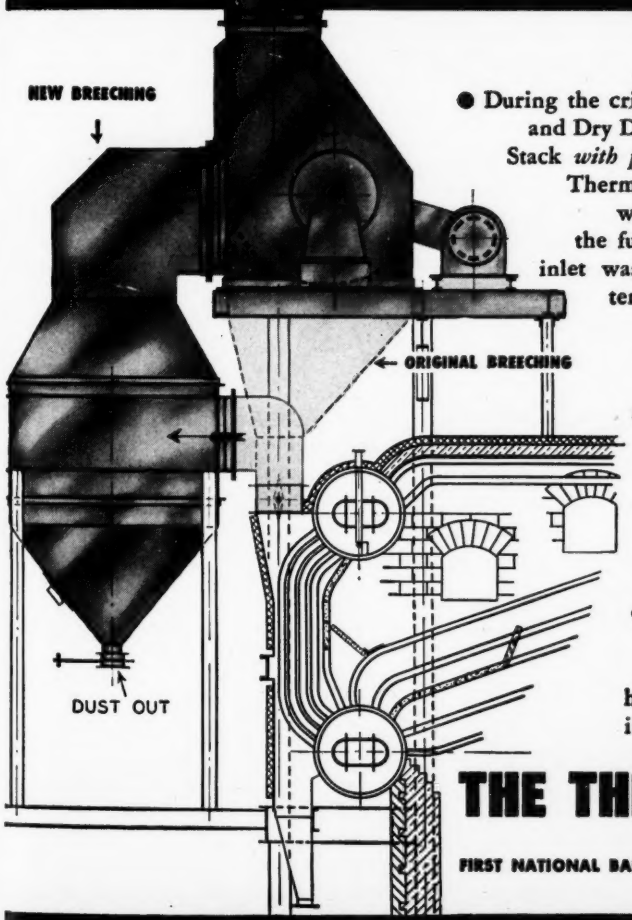
The new turbine generator at Essex Station will operate at a steam pressure of 1250 psi and a temperature of 950 F, and the boiler will be equipped to fire pulverized coal or fuel oil, or a combination of the two. The new generator will revolve at 3600 rpm and will be cooled by hydrogen gas which is recirculated in a closed system containing water coolers to maintain proper operating temperature. When operating at full capacity, the new generating unit will burn 900 tons of coal or 4000 barrels of fuel oil daily.

The new turbine generator will be connected directly to the 13,000-v substation at Essex Generating Station, from which its output will be distributed to substations in the Newark-Elizabeth area. By means of step-up transformers and the company's 132,000-v transmission system, the machine capacity also will be made available to the entire Public Service electric system.

The Federal Shipbuilding and Dry Dock Co.

ENGINEERED for the FUTURE

—, 'fave You?



● During the critical shortage of steel, the Federal Shipbuilding and Dry Dock Company of New Jersey installed a Thermix Stack *with provisions for a dust collector at a future date.* A Thermix Fan Stack with both a side and bottom inlet was used. The side inlet was blanked off for use in the future installation of the dust collector; the bottom inlet was directly connected to the boiler outlet. This temporary breeching, from the boiler to the ID fan, is indicated in the illustration by dotted lines.

Now that steel is available, the Thermix Tubular Dust Collector has been added to the original stack installation. Placing it in operation necessitated only the removal of the duct from boiler to stack and connection of collector to boiler and side inlet of the fan. The original bottom inlet of the fan was then blanked off.

Thermix collectors have the distinct advantage of both flexibility and extremely high collection efficiencies over a wide range.

Call on our project engineers, the Thermix Corporation, for more detailed information on how your plant equipment can be designed and installed to permit future additions.

THE THERMIX CORPORATION

Project and Sales Engineers

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Modern facilities and qualified welders assure the excellence of ADSCO Products whether built under the ASME Code or for the rigid requirements of the U. S. Bureau of Navigation and Steamboat Inspection, American Bureau of Shipping, U. S. Navy and U. S. Army.

Write for Bulletins No. 35-75 and 35-76 on ADSCO Storage and Instantaneous Water Heaters, or give us details of your heat exchanger requirements for quotation.

AMERICAN DISTRICT STEAM CO.
NORTH TONAWANDA, N.Y.

HERE'S MUD in Your IQ is another one of those pieces by Weare Holbrook that are classed as humorous writing but are really shrewd observations on people and things that seldom rouse belly-laughs but keep your cheek muscles twitching. This one, presented in The Amsco Bulletin is all about the absorption of persons of relatively low intelligence and ability into our industrial system, where jobs are fitted to their capacities, thus accounting for the fact that we have full employment. In short, modern industry can use even the village idiot for *some* useful job, however elementary. The story of Obie the village nit-wit, as told by Mr. Holbrook, will keep you snickering. Furthermore, Mr. Holbrook points out, education is rampant. What is the result? Hear Mr. Holbrook!

"Aunt Eulalie, for example, is the head of a clubwomen's foundation which furnishes funds to put poor but deserving girls through state normal school. A laudable enterprise, certainly. Yet Aunt Eulalie and her fellow-members are loud in their complaints about the servant shortage—never realizing that their own philanthropic activities are largely responsible for it. With the best intentions, they turn hundreds of potential kitchen maids into indifferent schoolma'ams. And most of those schoolma'ams eventually get married, set up housekeeping, and begin wailing about the servant shortage themselves.

"The time may not be far distant when there will be nobody left to do the drudgery in the world. According to a hard-boiled medical friend of mine, the best way out of such an impasse would be to equip all obstetricians with large padded mallets. With these mallets, every third child would be bopped gently on the head at birth—not too hard, but just enough to make it impervious to education in later life. Then we would always be assured of somebody to wash dishes, dig sewers, and whistle at radio broadcasts."

WET WATER is a new weapon for man's battle against disastrous forest fires and other fires, as revealed at the annual ASME meeting. It is a newly developed concentration of organic chemicals of such extremely fast penetrating action that, added to water in small amounts, it increases the extinguishing action of the water 200 to 400 per cent. Water impregnated with such wetting agents is known to chemists as "wet water."

The new "penetrant," known as "Unox," was used with considerable success last November in the extensive forest fires on the east coast, notably in Westchester County, N. Y. A limited amount also was sent to Maine by airplane for use there.

Normal use calls for 1 part of the penetrant to 100 parts of water, in some cases less. Although it is not cheap, the cost becomes small when evaluated in terms of dollars saved through more efficient fire fighting.

In a large building fire, thousands of gallons of water may be poured on without apparent effect, because only a small portion of the water is actually reaching the heat. This heat is in the burning material and the water, to be effective, must penetrate the material to whatever depth the temperature is high enough to cause decomposition of the solid matter into gases. Any means of increasing the speed with which water will penetrate the charred surface will increase its efficiency.

COMMUNITY CENTER

The McCarthy Center, now under construction in Houston, Texas, will comprise the 18-story Shamrock Hotel; a garage to house 1,275 cars; a shopping center of several buildings; a theatre seating 1,750, complete with concert stage; a 50-meter swimming pool; and a 15-acre parking lot.

Stone & Webster Engineering Corporation are the project managers for the construction of this comprehensive community center.

WYATT C. HEDRICK, ARCHITECT

STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER, INC.

Construction of the Gorge Plant Addition

This addition to the Gorge plant will house a new 44,000 kw turbine generator, a new steam generator and all auxiliary equipment . . . The site of the addition, on a high bank overlooking the Cuyahoga River, presented some unusual problems to the construction engineers . . . Only area for entrance of equipment and materials was through the yard at the rear of the plant . . . Many new methods of earth moving had to be devised to cope with difficulties . . . Erection of a skip hoist and a coffer-dam were initial steps in construction work . . . Details of concrete and pouring

By R. A. GALBREATH *Project Superintendent, Ohio Edison Co.*

THE NECESSITY of an ample water supply for steam-electric generating stations frequently leads to some unusual and difficult methods in plant construction. Sites that engineers normally would consider undesirable for the erection of a building the size necessary to house generating units sometimes become the best, and only, sites suitable.

Such a situation is the one facing construction engineers presently engaged in building an addition to Ohio Edison Co. Gorge steam-electric generating station in Akron. The addition will house a new 44,000-kw turbo-generator and steam generator, together with all necessary auxiliary equipment.

The site of the addition is at the foot of a steep slope of the Cuyahoga River gorge, adjacent to the present Gorge plant. The building will occupy an area 85 by 155 ft, and will stand 130 ft high.

The underlying foundation is of hard blue shale with 30 ft of soft sand and earth overburden. The top of the bank is only 200 ft away from the edge of and 100 ft above the pond at normal surface elevation.

Construction difficulties became apparent when the site of the addition is considered. The west wall of the building will join the present plant; the area adjacent to the east wall (open end) is inaccessible for moving equipment into the area because of the steep embankment (30 deg); the north (pond side) wall faces the river, which is non-navigable for river craft or barge-based construction equipment.

The only area of entrance for materials and equipment is through the yard at the rear of the plant, and even this is restricted. The yard along the top of the bank is 100 ft wide and 1,000 ft long. In this area must be located all the buildings, storage and activities necessary for construction operation. In addition, the yard is cut by a deep ravine which is crossed by a railroad trestle parallel to the rear of the plant. Over this 25-ft wide trestle is moved all construction area, and a large crawler crane is located on the trestle.

In addition, through this bottleneck must also pass the daily delivery of 1,000 t of coal to the present plant's coal bunkers.

This general situation plus the short construction period (June to February to be ready for super-structure steel erection) necessitates a daily three-shift schedule of operations.

As might be expected, therefore, many of the usual methods of excavation and construction had to be discarded and new ones devised. Fortunately, there is available along the east wall of the present plant a gantry-type, 100-t traveling crane that was installed when a plant addition, similar to the one now being built, was erected in 1942. This crane was provided for moving material from the railroad trestle at the top of the embankment to platforms at the fan floor level in the boiler room and at the turbine room operating floor level in the east wall of the new addition.

This transfer crane has been invaluable in lowering preliminary construction equipment into the construction area after it has first been moved onto the trestle.

Beside this crane, a guy derrick was built on the platform at the turbine room level (on the pond side of the plant) that can reach all points in the construction area not accessible to the traveling crane.

These two pieces of equipment, plus the crawler crane on the trestle, are the means for transferring material into the area.

To provide for removing spoil after excavation on the slope began, a

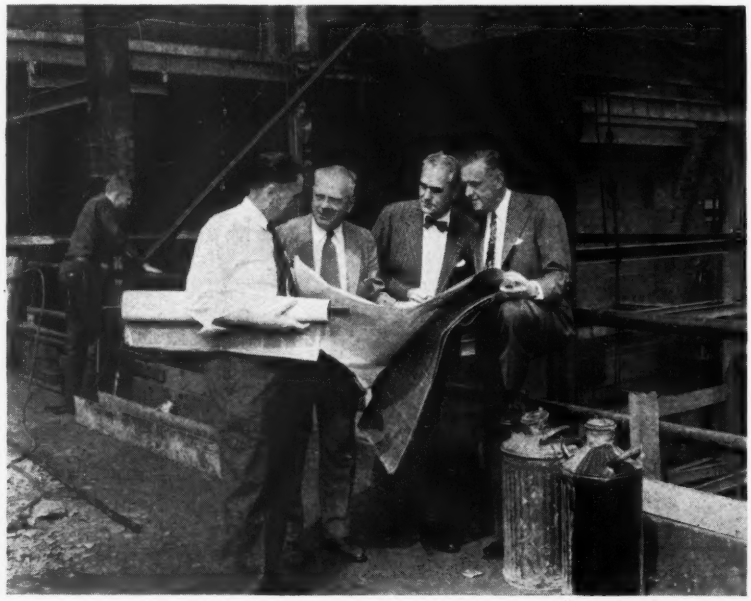

Fig. 1. Studying plans for the project are: R. A. Galbreath, project superintendent and author of this article; Frank W. Funk, Chief Engineer; Samuel Stites, vice president and Akron Division Manager; and LaVerne I. Wells, Co. secretary

Peabody Solves

COMBUSTION *Problems*

Whether it's a problem requiring versatility of fuel-burning capacity, wide-range operation, increased efficiency, decreased costs, or some certain problem unique to your individual plant, you can depend on Peabody Engineers and equipment to solve your combustion problem efficiently and effectively.

A few recent typical Peabody installations . . .

● A large West Coast utility required a standby steam plant that could pick up a full load of 75,000 KW *instantly* from 5,000 KW — without warning — in case of hydro failure. Peabody's extreme Wide Range Constant Differential Pump System and other Peabody equipment actually delivered on test 670,000 lbs. of steam in *5 seconds!*

● A large housing development required not only an extremely efficiently controlled heating plant for 1,200 families but also several unusual requirements in regard to safety, maintenance and accurate control — not to mention drastic architectural limitations on allowable stack height. Peabody Burners, firing under positive furnace pressure and minutely controlled, permitted smokeless operation with only a *6-foot* stack!

● A famous, large Eastern hospital required increased steam capacity but lacked physical space for additional boilers. Peabody Engineers and Peabody equipment converted the plant from coal to oil, and delivered the required increase in load even though furnace dimensions were extremely restricted.

If you have a combustion problem — no matter what the fuel may be — on any boiler from 100 HP and up, contact your nearest Peabody representative or write direct.

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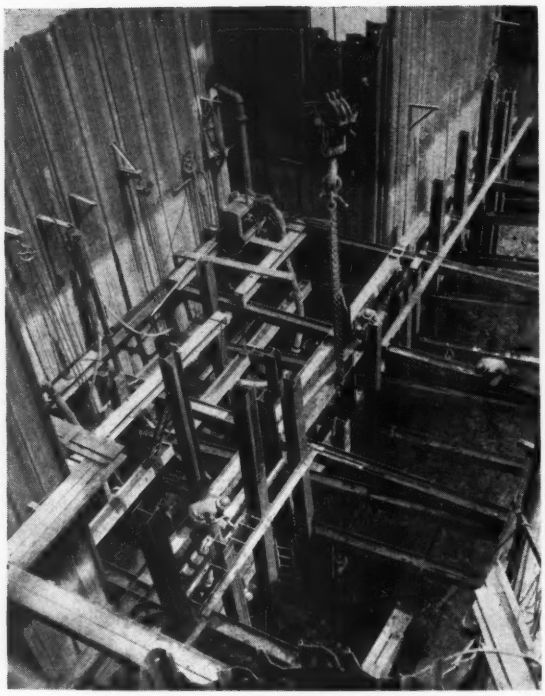


Fig. 2. This photograph shows the inside of the front wall cofferdam, 22 ft below the level of the river. Three sets of prefabricated H-beam steel bracing is shown in place

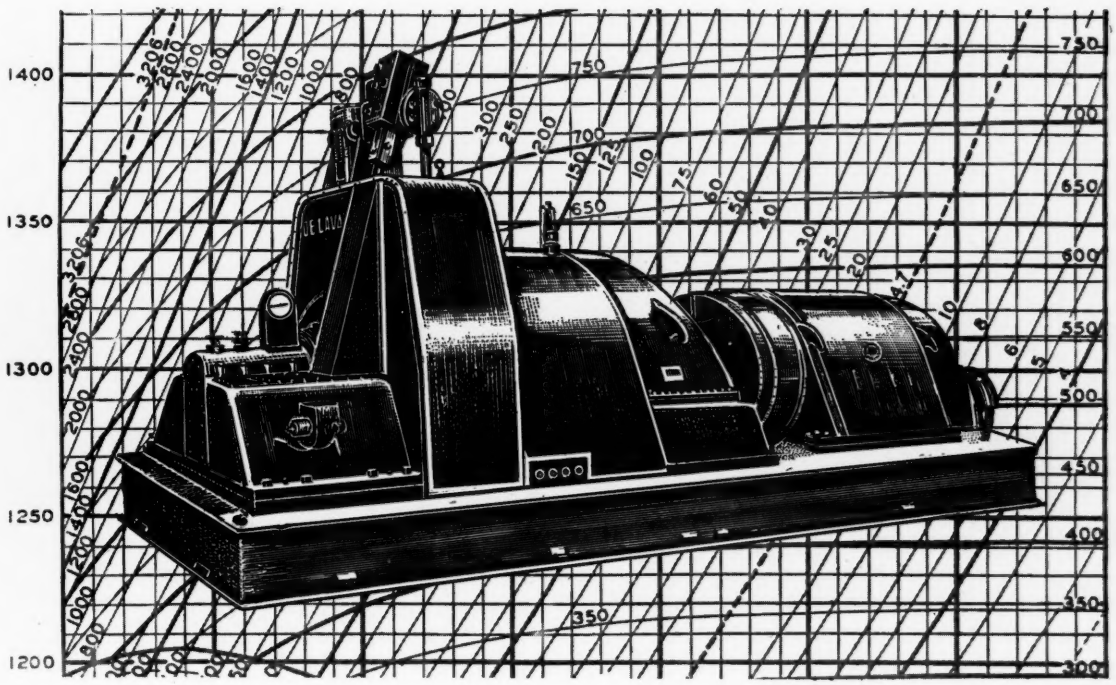
Fig. 3. Shown in this photograph are the bottom of the skip hoist in the base slab excavation and a power shovel which was used to load the spoil on the skip hoist

300-ft three-yard skip hoist was built from the foot of the embankment up to yard level. The hoist runs diagonally up the bank to a hopper above the yard level and dumps spoil into trucks to be hauled away. To avoid congestion, the hopper is located at one end of the railroad trestle instead of being directly in back of the construction area as it normally would be.

After completion of the skip hoist, an L-shaped cofferdam of steel sheet

Fig. 4. Here a tractor equipped with a bulldozer pushes shale loosened by blasting from the L-shaped cut for the rear and east walls to the base of the skip hoist where it will be carried to the top of the embankment

Fig. 5. Railroad trestle at rear of new addition. Over this 25 ft bridge must pass all equipment and materials. The hook of a gantry-type crane is shown in the foreground, a 100-ton power shovel is on the trestle



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from process steam

If you use appreciable quantities of steam consider the economy of generating all or a part of your own power by allowing the steam to expand through a De Laval Turbine before delivery to the heating or processing system.

De Laval Turbines can be furnished with automatic controls designed to make exhaust steam available in the quantities and at the pressures required to meet the demands of plant operation and the requirements of thermo-dynamic economy.

May we have the privilege of submitting cost figures based upon the installation of a De Laval turbine selected to meet your plant requirements? T-7

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Fig. 6. The blasting crew lowers a blasting mat on charges set in the cut in the rear wall

pile was constructed back of the rear wall so that excavation could be made for rear and end wall concrete, self-supporting retaining walls. This piling was driven from the crawler crane atop the trestle.

With this cofferdam in place, a shelf was cut in the bank at the base of the skip hoist and a power shovel lowered to it by the traveling crane. Excavation was begun for the retaining walls and earth and shale, loosened by blasting, was moved down to the shovel by a bulldozer, loaded on the hoist and removed.

Then began excavation for the base slab. The bottom of the base slab will be at pond level and will extend into the bank 150 ft. This necessitates a deep excavation for the rear wall.

This shelf, 80 ft below yard level, with the bottom on a level with the river, was cut and blasted out of the slope, all spoil being shoved over to the skip hoist, loaded and removed.

Cofferdam Construction

While the embankment was being cut away, work was begun on the pond side cofferdam. The "H" pile foundation (30-ft), front wall and intake structure is being constructed within the enclosed steel sheet pile cofferdam, driven out from the river bank in 20 ft of water. The steel piling was driven from the guy derrick located on a platform of the old building.

The guy derrick was also used to excavate under water inside the cofferdam, using a clam shell bucket. Then the bottom set of three sets of steel "H" beam bracing was fabricated above the water line and welded into a complete unit.

This unit, weighing 20 t, was lowered into place by means of ten 2-t chain falls spaced uniformly around the cofferdam walls. Steel cables were attached to the bracing unit and tied to the piling before lowering so that it would be suspended at the desired elevation.

This same procedure was used for two other sets of bracing before the cofferdam was unwatered.

In excavating inside the cofferdam it became necessary to handle spoil still another time. Inside the cofferdam, spoil was loaded in a wooden box and hoisted over the piling by the guy derrick to be dumped on the base slab shelf. It was then scooped up by the power shovel and loaded on the skip hoist to be finally removed. This triple handling of spoil gives an idea of just one of the difficulties encountered because of the restricted area for construction operations.

How Concrete Was Poured

After forms were built for the front, rear and side walls, came the problem of pouring concrete. Concrete work was further complicated by the fact that no space was available, either at yard level or inside the excavation, for concrete mixing equipment.

The solution was transit-mixed concrete, hauled to the trestle up at yard level and dumped down into the forms via chutes. These chutes necessarily must lead from the trestle down to the front, end and rear walls some 100 ft below. In some cases, the ready-mixed concrete travels as far as 200 ft.

A similar operation will be used in pouring the 5-ft thick base slab, which will be anchored on a rock bed.

A further idea of the project can be gained from the quantities of materials involved in the substructure alone. There were 5,000 cu yd of earth removed; 8,000 cu yd of shale; 162 t of steel sheet piling used; 27 t of 12-in 74-lb "H" piles; 80 t of "H" beam cofferdam bracing; 163 t of reinforcing steel; and 3,300 cu yd of concrete.

The substructure is expected to be completed by February, 1948. Excavation was begun in May, 1947. The plant addition is expected to be put into operation in the fall of 1948.

Fig. 7. Overall view of substructure work. Power shovel used to load skip hoist and guy derrick are visible

Good Equipment, Correctly Applied!

THAT IS THE BASIS of effective conditioning of boiler feedwater makeup . . .

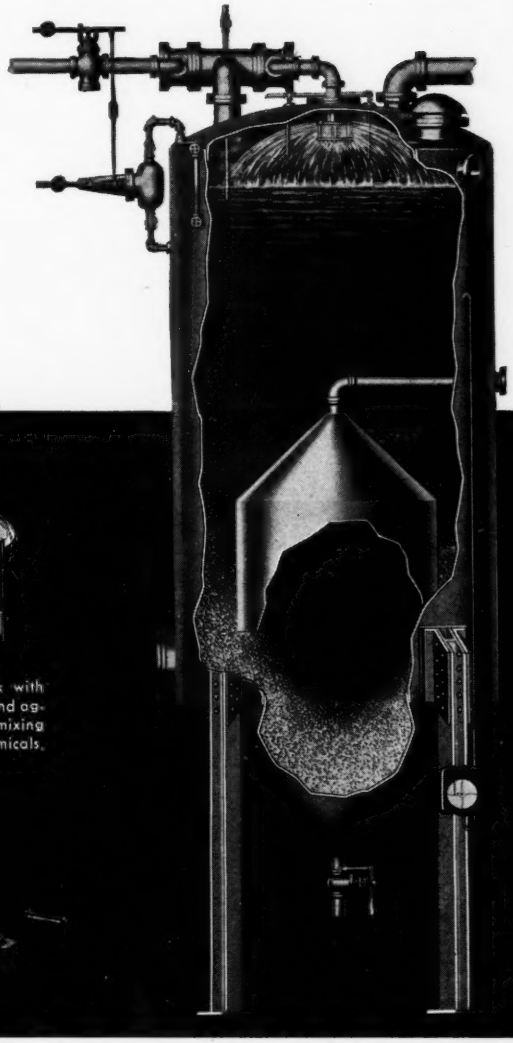
Long experience in conditioning boiler water in thousands of high and low pressure power plants qualifies Allis-Chalmers to assist you in selecting the *best* process and the *right* equipment for your plant.

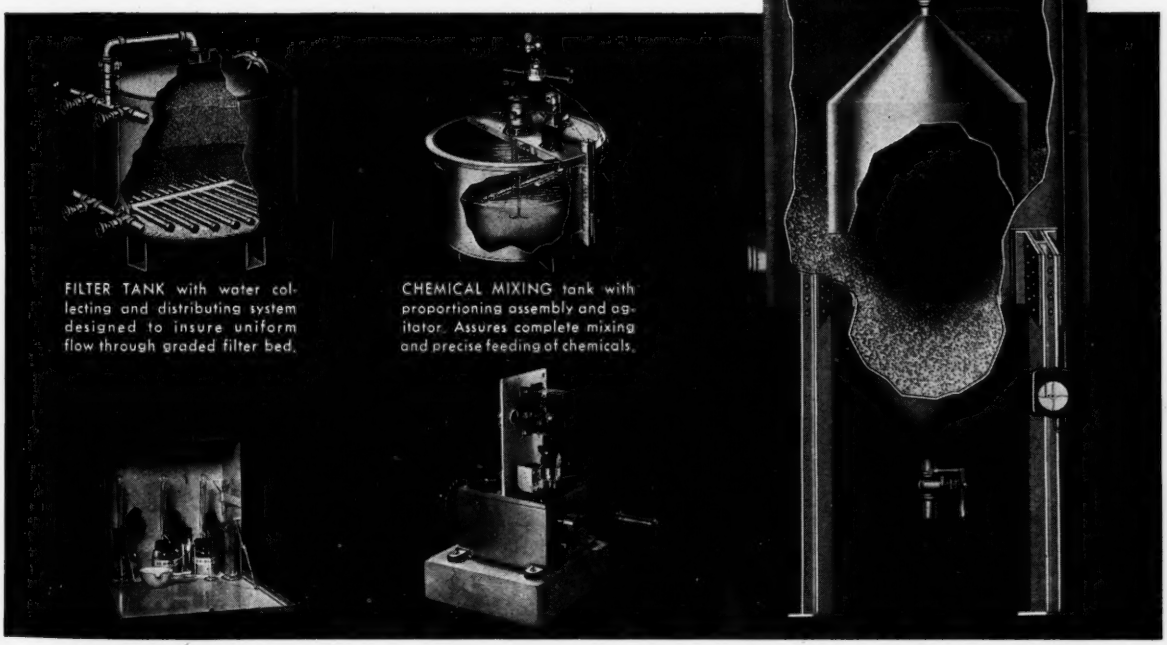
Allis-Chalmers recommendations are unbiased because they provide a *complete* line of water conditioning equipment including Hot and Cold Process Softeners, Sodium and Hydrogen Zeolite Softeners, Degasifiers, Deionizers, Chemical Proportioners, and Oil Removal and Water Filters.

For prompt help, call your nearest A-C office or write: ALLIS-CHALMERS, MILWAUKEE 1, WISCONSIN.

★ ★ ★

Illustrated below are component parts of Allis-Chalmers Hot Process Lime-Soda Softening System. Bulletin 28B6611 offers complete details. A 2340





FILTER TANK with water collecting and distributing system designed to insure uniform flow through graded filter bed.

CHEMICAL MIXING tank with proportioning assembly and agitator. Assures complete mixing and precise feeding of chemicals.

TEST KIT for treated water analysis and making adjustments in chemical treatment when composition of raw water varies.

ELECTRO-MAGNETIC proportioner with dust-proof cover removed. Vernier adjustment permits micro-control of chemicals fed.

SOFTENER TANK constructed to provide proper flow velocities for effective chemical reaction and sludge sedimentation.

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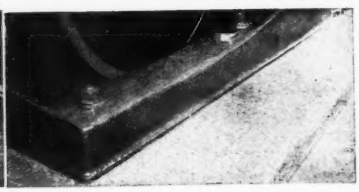
Study these views of broken and cracked frames and crankshaft. They will give you an idea of the big savings in time and money Metalock casting repair service is delivering in plants all over the country . . . Metalock repairs, made only by workmen thoroughly trained in this patented process, have been proved and accepted by manufacturers, users, underwriters.

STEAM ENGINE FRAME

Before

After



20 IN. DIESEL CRANKSHAFT

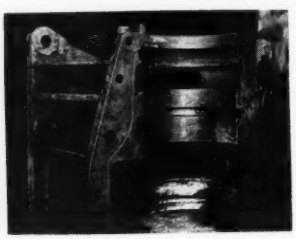
Before

After

PLUMMER BEARING (Navy Photograph)

Before

After



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WATER CONFERENCE

(Continued from page 89)

1. In no case should a temperature higher than 150 F be employed.

2. The shortest possible time compatible with satisfactory cleaning should, of course, be used.

3. The lowest possible concentration of acid that will accomplish the desired results should be used.

4. With numerous inhibitors now available, the selection of the best one and the optimum concentration thereof, would be a rather large laboratory program.

5. After complete observation of the results described, we are certain that the greatest problem in acid cleaning of boilers is that of obtaining thorough contact of all acid exposed surfaces with a neutralizing chemical or solution.

6. If all the factors, of temperature, time, solvent concentration and rinsing are properly considered, the effect of repeated acid cleanings would be nearly negligible.

7. It is the experience of the author that most power plant personnel fear acid. On the other hand, they are prone to ignore the many dangers attending its use for cleaning boilers.

The author stated that he would not hesitate to employ acid cleaning at any time that it seemed necessary or advisable. There are many advantages to be realized from the careful application of inhibited acids. Each individual boiler cleaning problem should be carefully approached and procedures based on an overall study of the situation.

I. B. Dick of the Consolidated Edison Co. of New York described the successful removal of water soluable deposits from turbine blades by washing with caustic soda. The procedure, the author said, is of a chemical nature and should be carefully supervised by competent chemists, each turbine to be cleaned constitutes a separate problem and must be studied individually. The general principles which he described must, therefore, be applied to each individual machine. Where this has been done in the author's experience, satisfactory removal of silica deposits has been accomplished.

As a matter of routine maintenance, the six condensing turbines in the station under the supervision of the author are each caustic washed about every two months. The feed-heating turbines also are caustic washed but at somewhat lesser frequency. The topping turbines, with the exception of one unit for a short time do not lay down insoluble silica deposits and so are not caustic washed.

Important among the controlling factors are temperature, concentration and time. Silica deposited on turbine blades will not dissolve in caustic soda solutions at atmospheric pressure and normal boiling tempera-

What Building Material?

K & M "Century" ASBESTOS CORRUGATED

What will determine the choice of building materials for your new plant, or remodeling job?

Will it be—

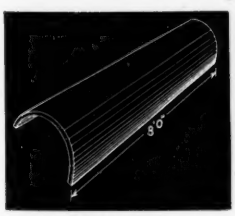
Appearance?
First cost?
Construction economy?
Speed of application?
Resistance to fire, weather, rust, other conditions?
Strength, durability?
Freedom from painting and other upkeep?

Regardless of which of those qualities you seek, K&M "Century" Asbestos Corrugated is an ideal choice, for it incorporates *all* of them in every rugged sheet. Being made of indestructible asbestos and Portland cement, it can't burn, can't rot, can't rust. Considering these many advantages, its cost is moderate, and it will pay for itself many times over in long maintenance-free life.

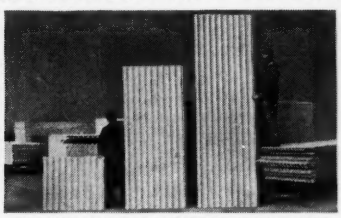
"Century" Asbestos Corrugated is easy to cut with portable electric or band saw, and easy to drill for drive screws or bolts. Cutting and fitting time is held to minimum because of 19 available sheet lengths. Salvage value is practically 100%.

If you'd like further information about "Century" Corrugated, write us, we'll be glad to help you.

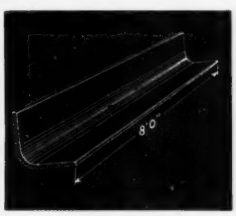
INSTALLATION DETAIL



RIDGE ROLL



VARIOUS SHEET LENGTHS AVAILABLE



CORNER ROLL

Nature made Asbestos . . .
Keasbey & Mattison has been making it serve mankind since 1873

Reg. U. S. Pat. Off.

KEASBEY & MATTISON

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IN CANADA — ATLAS ASBESTOS CO., LTD. • MONTREAL, TORONTO, WINNIPEG and VANCOUVER

that means

$AVINGS FOR YOU

The water or liquid to be measured enters the measuring chamber tangentially, spinning in the chamber as it passes through, forming a vortex. Each gallon that passes through this chamber makes the same number of revolutions of the water. The vane in the rotating water imparts the rotation to the register of the

HENSZEY *FEED WATER* METER

Yes, — it's as simple as that. No close clearances . . . no complicated mechanisms — all of which means savings for you. Savings in installation, savings in continued performance, savings resulting from accurate measurement of the liquid.

Henszey Meters are equally accurate at high or low flow . . . high or low pressures . . . on reciprocating or centrifugal pumps. Calibrations can be made to read in gallons, pounds or cubic feet at any specified temperature.

If you have a tough measuring problem that involves boiler feed water, boiler blowdown, condensate, chemicals or other hard-to-measure liquids, consider a Henszey Meter . . . contact your nearest Henszey representative or write to

HENSZEY CO., DEPT. C2, WATERTOWN, WIS.

HENSZEY

FEED WATER METERS

Continuous Blowdown • Distillation Systems • Heat Exchangers
Boiler Feed Regulators • Flow Indicators • Proportioning Valves
also MILK EVAPORATORS and PRE-HEATERS

ture. However, in a turbine at elevated temperatures it reacts quite rapidly. Concentration of caustic soda solutions will be adjusted automatically in a hot turbine by evaporation of excess water until the boiling point of the resultant solution is the temperature of the turbine. It was stated that samples from bleed points during a caustic wash have at times shown as high as 600,000 ppm NaOH or 60 per cent solution when injecting a 20 per cent solution at throttle. Time of contact is under the control of the operator as was explained in detail by the author.

If the following fundamentals are painstakingly applied to each job, the author stated, silica deposits can be removed from turbine blades with a caustic:

1. High temperature in the turbine.
2. Adequate caustic soda. Probably 400 lb will be consumed in washing a moderate sized unit.
3. Plenty of water during the rinse.
4. Consideration of safety of personnel and of equipment.

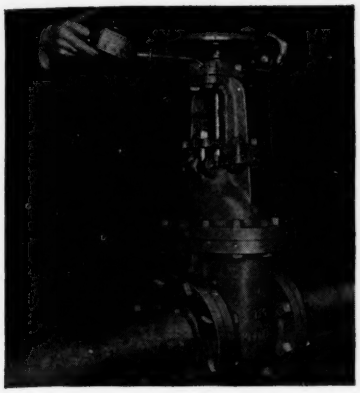
Corrosion Due to Micro-Organisms

In presenting a paper involving the biological reactions of polluted industrial waters on copper bearing alloys, C. O. Evans of the Phelps Dodge Copper Products Corp. emphasized the fact that the industry is entering into a realm about which there is much conjecture but of which little is known. However, if the presentation of certain known facts leads to an aroused interest in the effects certain micro-organisms, that abound in countless numbers of polluted industrial waters, have on metal, particularly non-ferrous, and this aroused interest results in a more intent study and research in the life processes and end products of these micro-organisms, this paper will have marked another milestone in man's battle against the corrosive elements nature has so bountifully presented to us.

The author's discussion dealt primarily with biological reactions on condenser tubes for the reason that probably no place else in the world do copper-bearing alloys, in such vast tonnages, come into more contact with polluted water than they do in the condensing equipment of power plants, steamships and exchangers in the petroleum industry.

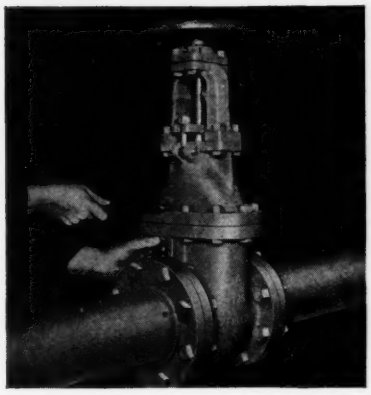
"Now that we are aware," stated Mr. Evans, "that both sulphuric and nitric acid can be produced on the surfaces of metals by the bacteria route, where polluted industrial waters are involved, and lay the foundation on the exposed metal for the support of various types of bacteria and their complex biological reactions, it is possible to comprehend that most, if not all, copper-bearing alloys are soluble in the acids which are end-products of many of these organisms and I submit it is reason-

MAINTENANCE IS EASY when you use Kennedy Valves

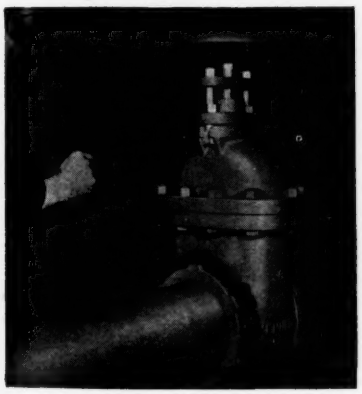


Kennedy Valves are designed for easy maintenance. This Kennedy Iron-Body Wedge Gate Valve, for example, is easy to lubricate. A conveniently-located oil hole is provided in the yoke cap . . . accessible even when the valve is closed.

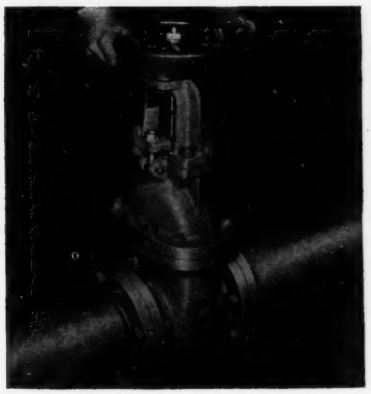
Repacking the gland is easy, too. Gland bolts need only be loosened and swung out, and the packing gland lifted on the stem and rested on shelves inside the yoke, out of the way. It may be packed under pressure when valve is wide open.



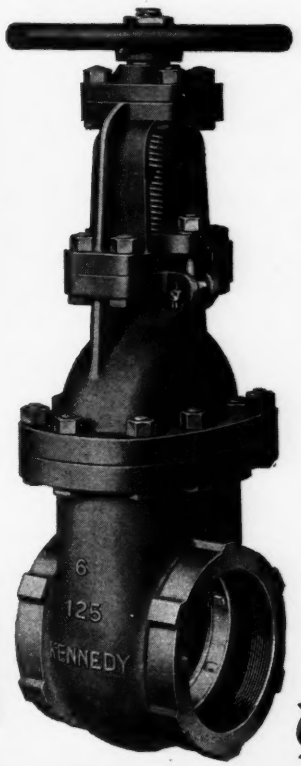
All bolts on body, yoke and flanges are readily accessible, with ample room for swinging the wrench. Nuts are on top of the yoke flange—not underneath. Gland bolts have washer nuts to eliminate the nuisance of loose washers.



On screwed end valves, lugs are provided around the outside of the end connections for convenience in applying a pipe or chain wrench.



Operation of the valve, too, is easy. The large-diameter hand-wheel provides ample leverage for effortless opening and closing of the valve.



The Kennedy Iron-Body Wedge Gate Valve is only one of hundreds of Kennedy Valves, all designed for minimum maintenance, easy operation, and long service life. For details see Kennedy's 240-page Catalog.

THE KENNEDY VALVE MFG. CO., ELMIRA, NEW YORK
Offices and Warehouses in Principal Cities

KV-175

BUY FROM YOUR LOCAL DISTRIBUTOR

KENNEDY valves - pipe fittings - fire hydrants

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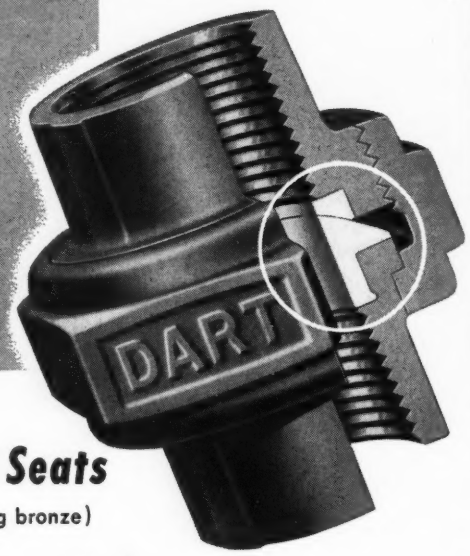
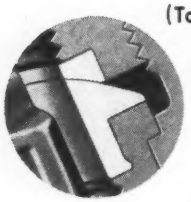
EXTRAS

in DART UNIONS



- **Extra-Wide Seats**
  (Made of non-corroding bronze)
- **Extra-Strong Body**
  (Made of air-refined malleable iron)
- **Extra-Heavy Shoulders**
  (To withstand strains and abuse)



And their two bronze seats are ground to a *True Ball Joint*

Darts maintain their leadership in unions by their ***extra-sound*** construction. Their two extra-wide bronze seats are spherical-ground to form true bearing surfaces, making a drop-tight connection. They uncouple without damage and without excessive wrench pressure, and can be used in other locations, as needed, again and again. Body and nut are made of high-test, air-refined malleable iron and are practically indestructible.

For long service at low cost, always specify Darts.

E. M. DART MFG. CO.
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DART UNIONS

able to believe that they have contributed their share to many so-called corrosion failures under conditions that were favorable for their existence and further development."

Brackish Water

For plants that must prepare brackish water for boiler makeup feed four processes are available, said O. M. Elliott of the Sun Oil Co. in his paper entitled, "Brackish Feedwater Treatment." His paper discussed the advantages and limitations of the distillation process, the ionization process, ion exchange softening process and precipitation softening process. The processes in operation for the treatment of brackish feedwater at the Sun Oil Co.'s refinery at Marcus Hook, Pa., were also described. Water treatment plants for this refinery combine the ion exchange and precipitation softening process to obtain advantages from each. 450 psig boilers are operated during brackish periods with boiler water concentrations between 10,000 and 20,000 ppm with no significant carry-over, scale or sludge formation.

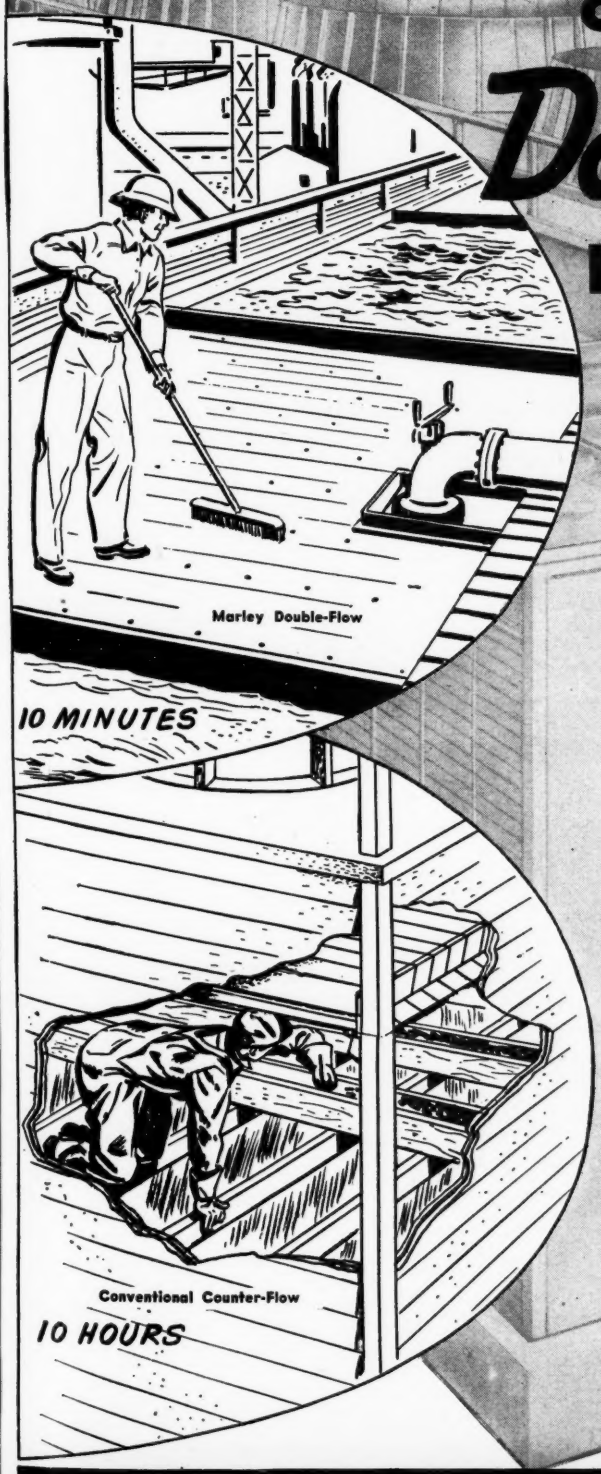
In a paper by Joseph Thompson and Francis X. McGarvey of The Resinous Products & Chemical Co. on "Some Practical Aspect of Deionization," the authors stated that in the early stages of the development of the Amberlite ion exchange resins, the major portion of their efforts were directed toward the refinement of the procedures used in the synthesis of the products and to the accumulation in the laboratory of preliminary information relative to their physical and chemical characteristics.

The thoughts of the authors on the application of deionization were presented by consideration of the following steps involved in the operation of both cation and anion exchange units. Each of these subjects were described in detail and considerable information on the results of this treatment were presented in the form of curves. Topics considered were: (a) backwash; (b) regeneration; (c) rinse; and (d) service flow. The authors pointed out that this process, introduced some seven years ago, provides a practical means of producing a water of a quality generally equivalent to that of single distilled but at a fraction of the cost of distillation. For all practical purposes the cost of regenerance may be considered to be approximately one cent per grain per gallon mineral solids as calcium carbonate removed for each 1000 gal of water treated. Because the major part of the equipment comprising the deionizing system must be constructed with acid resisting materials, the initial cost of even a small installation is sizable.

Production of pure, ion and silica-free waters by use of the Ionac ion-exchange resins acting to remove the ions originally present in the water was the problem discussed by A. V.

Only a CLEAN Cooling Tower Is Efficient

ONLY A MARLEY *Double-Flow* IS EASILY CLEANED



To maintain efficiency in any cooling tower, the distribution system must be perfectly clean to permit maximum break-up of water. As sediment and algae accumulate, distribution is retarded . . . performance curve lowered.

Only in the *Double-Flow* open distribution system can tower condition be ascertained at a glance. *It is not necessary to shut-down entire tower for either inspection or cleaning.* If cleaning is necessary, the Double-Flow may be cleaned in minutes . . . with no accident hazard involved.

Since it is so easy to keep the Double-Flow in perfect condition, operators accept cleaning as a routine part of operation. It is not an overtime task to be shunned as laborious and dangerous.

Open distribution is just one of many exclusive features that make Double-Flow the industrial leader . . . cooling 8 Billion Gallons of water daily.

MARLEY COOLING TOWERS

THE MARLEY COMPANY, INC. • KANSAS CITY 15, KANSAS

increase your boiler operating efficiency with Alken Certified SOOT-OFF

Works while boiler is in operation.
Not harmful to boiler metal or brick work.
The largest and smallest industries stop losses due to soot and slag in boilers with
ALKEN CERTIFIED SOOT-OFF*
A guaranteed product of

ALKEN • MURRAY CORP.

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Representatives Located In Your Area.

*Reg. U. S. Pat. Off.

WRITE FOR FREE SURVEY

Alm of the American Cyanamid Corp. The theory of the absorption, together with some of the economic aspects were discussed and a comparison was made of the chemicals' costs with those of the sodium fluoride method. The author stated that a series or preliminary tests have been conducted in which the combined cost of demineralization and silica removal compares very favorably with the calculated cost of this type of water prepared by demineralization together with removal of silica as a silica-fluoride ion. The results indicate the possibility that the cost, though already low, can be reduced greatly by proper regenerant dosage. The quality of the waters produced was stated to be exceptional with less than 2 ppm of gravimetric solids during much of the test run. The end points were at 2 to 4 ppm SiO_2 with the gravimetric solids usually 1 ppm above the colorimetric test for SiO_2.

Feeders and Controls

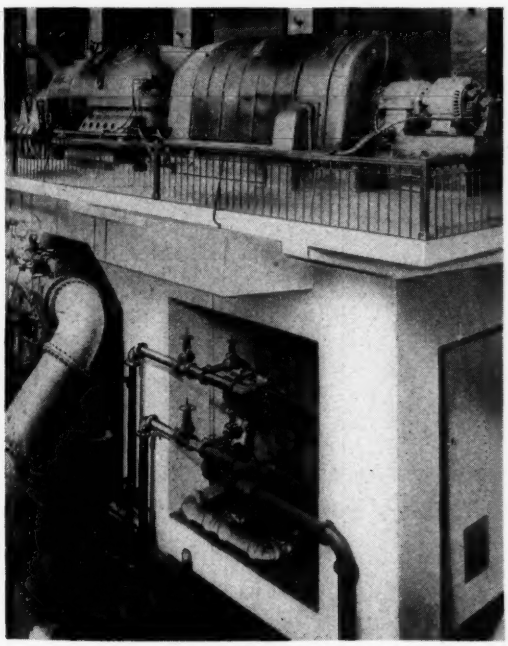
Chemical feeders, said Robert T. Sheen of the Milton Roy Co. in his paper entitled, "Liquid Chemical Feed Systems," may be classified by the form in which they handle the chemical—that is, either in the solid dry form by dry feeders or liquid form by solution feeders.

Dry feeders are normally indicated where larger amounts of chemical are to be handled each day and where gravity feed systems can be employed. Solution feeders are preferred for lower rates of feed and where the chemical is to be fed into a pressure system. The type of chemical will usually further indicate the best type of feeder; for example, ferric sulphate and ferric chloride are best handled in solution feeders at practically any rate. This paper dealt exclusively with the solution or liquid type of chemical feed system.

Practically all solution type feeders are based on the principle of introducing a known quantity of chemical to a known quantity of water, so that a chemical solution of known concentration is prepared. The volume of this chemical solution introduced to the water system is then controlled by various devices. Liquid chemical feed systems may readily be classified as gravity feed systems and pressure systems. The author described in detail several systems which had been designed for feeding chemicals, taking up the various elements such as proportioning pumps, tanks, control methods, piping systems, chemical feeders and other details which went into the design of these systems.

Discussing the question of Automatic Control in Corrective Water Treatment, W. N. Greer of Leeds & Northup Co., stated that in controlling the feed of reagents in the treatment of water, whether in treatment of raw water for plant use, or in the corrective treatment of process water

Do Your Generators Need Air Conditioning?



G-R

K-FIN GENERATOR AIR COOLER

A G-R K-Fin Air Cooler System is as far superior to ordinary forced draft circulation through generator windings as an air conditioning system is to a fan.

With open forced draft, the heat from generator windings is merely distributed through the engine room, dust accumulates in the windings, and the generator heat loss cannot be reclaimed.

By circulating the air for generator windings in a closed circuit and cooled by a G-R K-Fin Air Cooler, you obtain many benefits. Generator operation becomes quieter and cooler. Fire hazard is eliminated . . . the limited amount of oxygen in the closed system cannot support combustion. The windings remain clean . . . generator maintenance expense is reduced. Electrical heat energy can be recovered by using the condensate as the cooling medium.

The wide-spread recognition of these important advantages is indicated by the use of G-R Air Coolers with generators totaling well over 7,000,000 kw, ranging in size from 500 kw to 160,000 kw. Bulletin 1219 describes these units in detail . . . write for your copy.

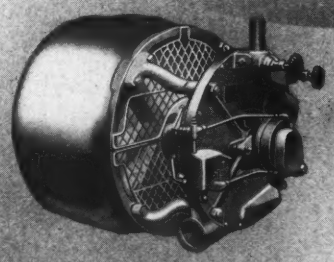
GR-194

THE GRISCOM-RUSSELL CO.
285 MADISON AVENUE, NEW YORK 17, N. Y.

GRISCOM-RUSSELL

Pioneers in Heat Transfer Apparatus

Wing

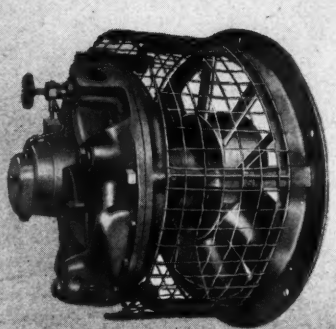


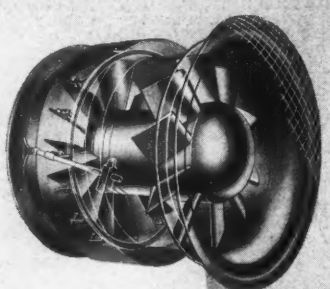
WING TURBINE DRIVEN BLOWERS
Type K
For Brickwall Mounting

Wing pioneered in forced-draft turbine blowers over a third of a century ago. Today Wing Turbine Blowers are in use in thousands of installations in many varied industries. They are simple and rugged in construction, quiet and dependable in operation. Oil-free exhaust can be used for heating, process or feed water.

WING TURBINE DRIVEN BLOWERS
Type R
For Horizontal or Vertical Mounting on Wind Boxes or Air Ducts

Ideal where use can be made of exhaust steam or where electricity is not available. Flexible capacity regulation by throttling steam to turbine—manually by hand valve or automatically by combustion control. Prompt shipments (no waiting for motors).





WING MOTOR DRIVEN BLOWERS
TYPE COM (TWO STAGE)
TYPE EMD (SINGLE STAGE)

Wing Motor Driven Blowers are axial flow forced draft blowers of simple, rugged construction, compact design and highest efficiency. Type EMD has capacities up to 50,000 CFM with statics to 5". Type COM can handle statics up to 30" on special designs.

Write for Bulletin SW-47

L. J. Wing Mfg. Co.
154 W. 14th St., New York 11, N. Y.
Factories: Newark, N. J. and Montreal, Canada

TURBINE BLOWERS • TURBINES • FANS • MOTOR DRIVEN BLOWERS
REVOLVING UNIT HEATERS • UTILITY WING HEATERS • FIXED DISCHARGE UNIT HEATERS
DUCT FANS • DRAFT INDUCERS • HEATER SECTIONS • SHIP VENTILATORS • FOG ELIMINATORS

for reuse, the final controlling factor is concentration. Various means are used for measuring the concentration depending upon the constituents, concentration, conditions under which measurement must be made, and sensitivity relation between the specific measurement and the concentration.

The automatic control of concentration within prescribed limits, depends not only upon the measuring and control equipment used, but to a great extent upon the variables in the system, such as rate of change of concentration of influent (untreated water) and changes in rate of flow, and also upon physical factors, such as the relative capacity of the treating system, time lags, etc. Furthermore, he stated, in some types of measurements, the control point is an important factor.

In his paper the author presented a means of determining process controllability within reasonable limits and described a few exemplary installations. The choice of devices for measuring concentration, he stated, depends upon the solutions involved, the particular concentration to be measured, sensitivity relation between measurement and concentration, etc. Usually the choice will be between electrolytic conductivity and pH, since in water treatment we are concerned with dilute solutions and in dilute solutions we obtain with these a high degree of sensitivity of measurement. In a few cases either pH or conductivity can be used and in such cases the preference, he stated, is for conductivity since the measuring device is simpler and the maintenance requirements are less.

Papers Presented at Eight Annual Water Conference*

Experiences with Acid Cleaning of Boilers at the South Omaha Steam Electric Station, by Elden K. Adkins, Chemist, Omaha Public Power District.

Removal of Silica Deposits from Steam Turbines by Caustic Soda, by I. B. Dick, Division Engr., Consolidated Edison Co. of New York.

The Use of X-Rays in Water Problems, by L. A. Burkardt, Chemist, Water Conditioning Dept., Allis Chalmers Mfg. Co.

The Biological Reactions of Polluted Water on Copper Bearing Alloys, by C. O. Evans, Phelps Dodge Copper Products Corp.

Treatment of Brackish Water for Boiler Feed, by O. M. Elliott, Sun Oil Co.

Method of Oxygen Determination in Boiler Feedwater (Heat Transfer Institute), by J. F. Sebald, Worthington Pump & Machinery Corp.

Some Practical Aspects of Deionization, by J. Thompson, Sales Development Eng., and Francis X. McGarvey, Chemical Engr., The Resinous Products and Chemical Co.

Silica Removal by Means of Ion Exchange Resins, by A. V. Alm, Ion Exchange Products Dept., American Cyanamid Co.

Liquid Chemical Feed Systems, by Robert T. Sheen, President, Milton T. Roy Co.

Automatic Control in Corrective Water Treatment, by W. N. Greer, Market Extension, Leeds & Northrup Co.

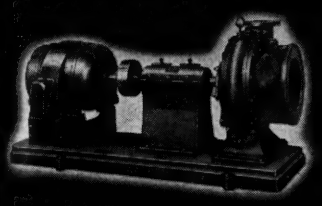
Pennsylvania's Stream Pollution Program, by L. S. Morgan, District Engr., Dept. of Health, Commonwealth of Pennsylvania.

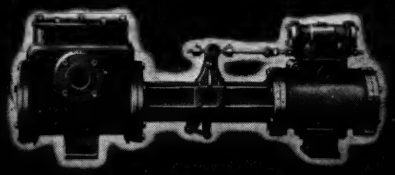
Engineering for Industrial Waste Treatment, by G. A. Rohlich, Assoc. Professor, University of Wisconsin.

How Some Troublesome Waste Water Problems Were Solved, by A. C. Embshoff, Chemical Engr., Infilco Inc.

* Mimeographed copies of these papers may be purchased from the Engineers' Society of Western Pennsylvania, Hotel William Penn, Pittsburgh, Pa.

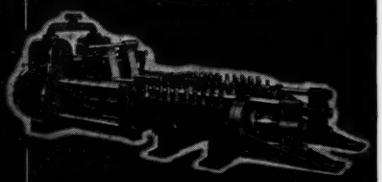
Warren Stock Pump
Type 5-SOD-15 . . . 12" suction nozzle





Warren Steam Heat
Vacuum Pump

Warren Horizontal Duplex
Hydraulic Pump



WARREN PUMPS

Maintain efficiency
Operate at low cost
Are long-lived

CENTRIFUGAL

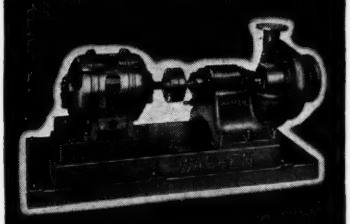
Single and multi-stage
Pressure range: 0 to 1200 P. S. I.
Capacities: 0 to 50,000 G. P. M.
Types: Horizontal and Vertical
Impellers: Open or enclosed
Casings: Horizontal or Vertical Split, cast iron or bronze
Bearings: Sleeve or ball-bearing

RECIPROCATING

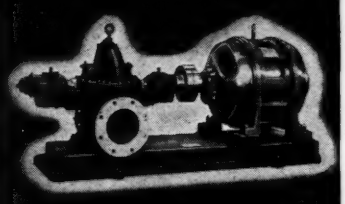
Horizontal and Vertical single piston
Horizontal and Vertical duplex piston
Single and Duplex Outside Packed Plunger
Single, Duplex and Compound Hydraulic
Steam Heat Vacuum
Automatic Pump and Receiver, etc., etc.,

Send your pumping problem to us; our Engineers will recommend the right pump for the job.

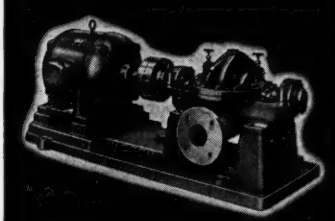
P 14



Warren Type "L" Single-Stage
Single-Suction Liquor Pump



Warren Double Suction Pump
Single Stage



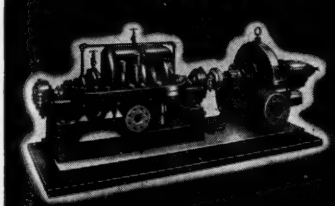
Warren Type DBL, Single-Stage
Double Suction, Centrifugal Pump

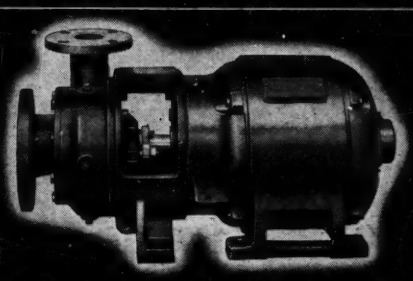
Warren Two-Stage Volute
Centrifugal Pump

WARREN STEAM PUMP COMPANY, INC.

WARREN, MASSACHUSETTS

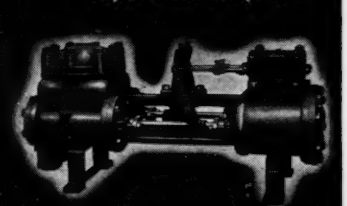
Warren Type TM, 4 and 6 Stage
Centrifugal Pump





Warren "Compacunit"—4 Types—42 Sizes

Warren Horizontal "Realwear"
Duplex Piston Pump



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Obituaries

WALTER G. ZIMMERMAN

WALTER G. ZIMMERMAN, 71, retired senior contracting manager of American Bridge Co., Hinsdale, died at the Hinsdale Sanitarium recently.

Mr. Zimmerman, who was born at Buffalo, N. Y., Oct. 25, 1876, received his preparatory education at the Harvard School for Boys in Chicago and the Wilhelms Gymnasium, Koenigsberg, Germany. He graduated from Massachusetts Institute of Technology in 1898.

After previous experience with the Illinois Central Railroad and various engineering firms, he became associated with American Bridge Co. in July, 1903, as a contracting agent. He was made contracting manager at New Orleans in February, 1907, and later served in the same capacity at Atlanta, Ga., and Duluth, Minn. In June, 1926, he was appointed assistant division contracting manager at Chicago and, five years later, became senior contracting manager, the position which he held when he retired Dec. 31, 1945.

Mr. Zimmerman had been a member of Sigma Chi, Chicago Engineers club, Western Society of Engineers, American Society of Engineers and the University club.

He is survived by his wife Helen and a daughter Elizabeth, both of Hinsdale; a son Walter of Omaha, Neb., a brother Herbert P. Zimmerman of Geneva, Ill., and two sisters, Mrs. C. P. Rockwood and Mrs. W. D. Bangs, both of Geneva.

JAMES G. BIDDLE

JAMES G. BIDDLE, A Philadelphia pioneer in the field of measuring instruments and Founder and Chairman of the Board of Directors of the James G. Biddle Co., died recently after a brief illness. He was 79 years of age.

After several years with the then well-known firm of James W. Queen & Co., which made scientific instruments, Mr. Biddle founded his own business in 1895, at a time when the electrical industry was in its early stage of development.

Mr. Biddle was responsible for the introduction of many electrical and scientific instruments to this country, being among the first to supply X-ray apparatus. This was of the Roentgen type. Through intimate personal contact with scientific and research laboratories, and later with utilities and manufacturing companies, Mr. Biddle supplied equipment such as Wolff precision potentiometers and standards of resistance that are still in use and highly valued.

Mr. Biddle was a member of the Society of Friends (Quakers) and was actively identified with various social service organizations during his active life. He was a fellow of the American Institute of Electrical Engineers, a member of the Franklin Institute and the Engineers Club of Philadelphia. He was widely known in American electrical engineering circles.

ALVA J. CHUBB

ALVA J. CHUBB, Publisher of National Engineer, official journal of the National Association of Power Engineers, passed away in the Methodist Hospital, Indianapolis, Indiana, recently, following several weeks of illness.

In 1932 he joined the staff of National Engineer as business manager, where he remained until 1937. In this capacity he gained a large circle of friends among advertising men, engineers and manufacturers in this field. In 1937 he joined the Kewanee Manufacturing Co., as Sales Manager where he remained until May, 1947, when he returned to National Engineer as publisher.

wide open . . . or shut tight — in a FLASH!

. . . with the Everlasting Valve

THE EVERLASTING "straight-through" Valve is used in all industry because a reliable, quick-acting, drop-tight valve is what industry wants.

That's why, when you require wide-open, full-pipeline flow in an instant, or split-second emergency shut-off . . . you can get it with an EVERLASTING Valve. Less than a 70° turn of the lever turns the trick.

What's more, the EVERLASTING Valve *improves* with use. The rotating action of the sealing disc against the seat gives the valve a self-lapped seal . . . *everlastingly tight.* For the design of the EVERLASTING Valve forces the sealing disc into constant contact with the sealing surfaces around the port. Damaging grit can't get in between.

Mechanically, the EVERLASTING Valve is simple. *It has but eleven parts in all.* Maintenance can't be a headache. And remember the self-lapping feature—it has no equal for maintaining the drop-tight seal. *Furthermore,* EVERLASTING Valves are designed to "take it." *And they do!*

Made in straight lever and rack-and-pinion types, the EVERLASTING Valve is available in cast-iron, bronze or cast-steel. Sizes range from ½" to 6"; pressures up to 300-lb. EVERLASTING Valves conform to A.S.M.E. and other code requirements.

If you have a fluid-flow control problem—our engineers can help. For complete information without obligation *drop us a line for Bulletin #E-150 — today!*

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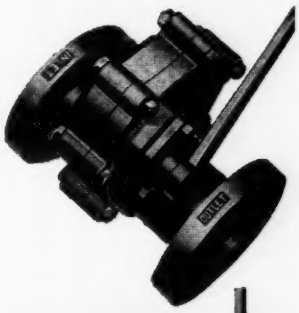
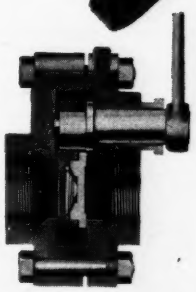
Flanged Straight Lever Type (Figure 1101) available for such services as Acids, Alkalis, Cellulose, Emulsions, Oil and Gasoline — as well as for Steam, Water or Air.





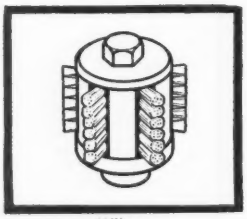
Cross Section View Screwed Type

To meet the fluid-flow requirements of all industry, the complete line of EVERLASTING Valves provides dependable, quick opening and drop-tight closing valves for:

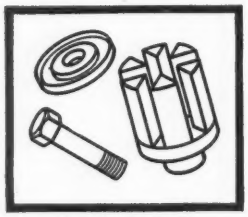
- Boiler blow-offs
- Water column shut-offs
- Air accumulators
- Condenser blow-offs
- Tank outlets
- Equipment throttles
- Plastic presses
- Evaporator blow-offs
- Loading rack lines
- Emergency shut-offs
- Process pipelines
- Laundry washers
- Vulcanizer blow-offs
- Fire protection lines
- Cleaner's and Dyer's vats
- Purifier blow-offs
- Compressed air tanks

XV-272

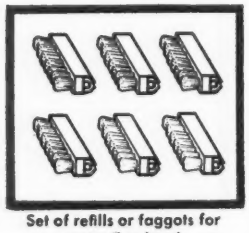
Everlasting Valves GIVE "EVERLASTING" SERVICE.



Wilson
Expanding Brush



Frame or body of
expanding brush



Set of refills or faggots for
expanding brush

Ten to twenty times as many tubes can be cleaned with a Wilson Expanding Brush than with ordinary sectional brushes before replacement is necessary. When removing the light, powdery deposits or for final polishing of tubes, the savings in time, labor and money derived from this feature alone make the expanding brush an essential part of very tube cleaning equipment.

This longer life results from the expanding action of the brush. Because any brush must be smaller than the I.D. of the deposit it removes, the ordinary sectional brush cleans by vibrating against the inner tube wall with a pounding action which hammers down the brush elements.

In the Wilson Expanding Brush, centrifugal force holds the tufts in constant contact with the deposit — eliminating this destructive pounding. Worn tufts in the Wilson Expanding Brush can be replaced easily and quickly — and at low cost.

A copy of the Wilson Tube Cleaners Check List will help you select the right Wilson equipment to do your tube cleaning jobs faster and more effectively. Write for your copy today.

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New ENGINEERING BOOKS

Overfire Jets and Controls for Locomotive Smoke Abatement, as revised August, 1947, by Eugene D. Benton, of Bituminous Coal Research, Inc., 912 Oliver Building, Pittsburgh 22, Pa.; price $0.25.

Overfire jets are an efficient and satisfactory auxiliary to proper operation of locomotives to prevent smoke. The author discusses the design and construction of jets for locomotives with instructions to help the shop engineer in making his own. Two types of jet construction are presented; type A and type B, each designed to fit the limiting dimensions of various locomotives. The varying methods of applying jets to switching, hand-fired and stoker-fired road locomotives is explained. Turbo-blower jets are discussed as well as diagrams showing how to hook up the controls. Numerous tables list performance, draft increase, relation of tube length to penetration, and air capacity.

Application of Overfire Jets to Prevent Smoke from Stationary Plants, as revised August, 1947, by Richard B. Engdahl and William S. Major, of Bituminous Coal Research, Inc., 912 Oliver Building, Pittsburgh 22, Pa.; price $0.25.

Written by research and development engineers this book furnishes the latest information on the application of overfire jets to stationary plants for the prevention of smoke primarily.

The book covers the problem thoroughly and makes no pretense of offering a cure-all for smoke prevention. The problems are analyzed, the jets constructed, and the location of the jets in the furnace discussed in a manner calculated to guide the operating engineer in his selection and application of jets to his own individual plant. The authors tell how to determine which type of jet and its location would be best, with examples of many types of furnaces and stokers, for each plant. Steam jets, steam-air jets, blower-air jets, and steam-flue gas jets are presented with the construction, penetration, steam or power consumption of each computed for standard installations. The relation of penetration and spread regulates the spacing and height of the jets above the fuel bed.

Engineering Drawing, by Thomas E. French; 7th Edition, 1947; 694 pages, illustrated; size 6½ by 9½ inches, cloth binding; revised by Charles J. Vierck; published by McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York City; price $3.75.

This is one of the "bibles" of the engineering draftsman and the engineer. It has gone through seven editions since its first printing in August, 1911, and has sold many thousands of copies. After successive additions and revisions during all this period, the book now is refined to a very high degree of practicality and efficiency, not only for the undergraduate engineering student but also for the practical draftsman in an engineering office.

The author points out in the preface to his first edition what is still fundamental in engineering drawing. After a knowledge of the technique of expression, the penmanship and orthography of the subject, the draftsman's whole energy should be directed towards training in constructive imagination to build up a clear mental image.

In the present edition the aim, as always, has been to keep abreast of modern engineering practices by eliminating the obsolete, revising the old and adding new material. Since the date of the preceding edition there has been much emphasis on pictorial drawing and on new standards and practices in dimensional. Some of this pictorial drawing, such as that used

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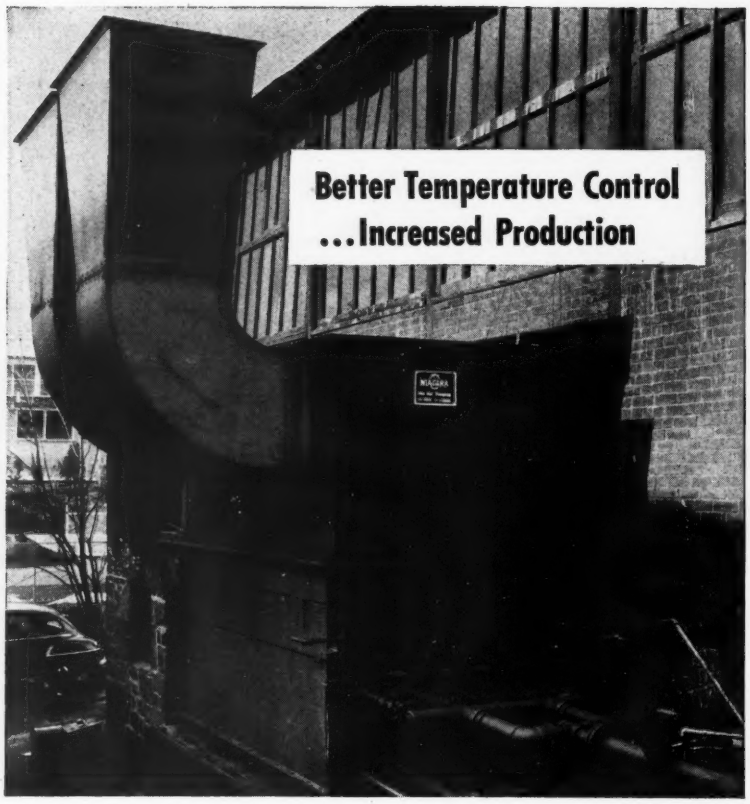

● Where the cooling of liquids or gases is part of your process, the NIAGARA AERO HEAT EXCHANGER will save over 95% of the water you use for cooling.

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in the well-known production illustration of the aircraft manufacturers during the war, has proved very effective not only in that industry but in many others. Several new projective methods and explanations have been included in this edition. The chapter on perspective and the chapter on dimensioning has been expanded.

One of the features of this book is that now a number of text films issued by the publisher are available; these are designed especially for and correlated with the text and problems. These visual aids, consisting of both motion pictures and film strips, are designed for use in drafting courses as an aid to the text.

The book begins with a discussion of the selection and use of instruments and a good treatment of lettering. Next are taken up the principles and applications of geometry, the theory of projection drawing, auxiliary views, sections and conventions.

Then follow a discussion of the drawings and the shop, dimensions and notes, dimensioning of machine drawings.

Subsequent chapters take up drawing of various specialized fields such as piping, welding, gears and cams. These are followed by chapters on technical sketching, pictorial representation, prospective drawing and various specialized types of illustrations and drafting techniques such as those used in architecture and maps. One of the concluding chapters gives very good data on the construction of charts, graphs, and diagrams. There is a chapter on commercial practices and a good bibliography of allied subjects, including a good list of American standards covering bolts, piping, symbols and abbreviations and the like, as produced by the American Standards Association.

An appendix contains practical and convenient tables that draftsmen need to use often, such as length of cord for circle arcs, metric equivalents, thread dimensions, bolt and nut dimensions, pipe size tables, abbreviations and symbols used in drawing and ends with a glossary of shop terms for draftsmen and a list of the industrial films available that should interest engineering draftsmen. The book is well indexed.

The Modern Gas Turbine, including Jet Propulsion, by R. Tom Sawyer; 2d 1947 Edition; 224 pages, illustrated; size 6 by 9 inches, cloth binding; published by Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, New York; price $4.00.

Gas Turbine Construction, by R. Tom Sawyer; First Edition, 1947; 411 pages, illustrated; size 6 by 9 inches, cloth binding; published by Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, New York; price $7.00.

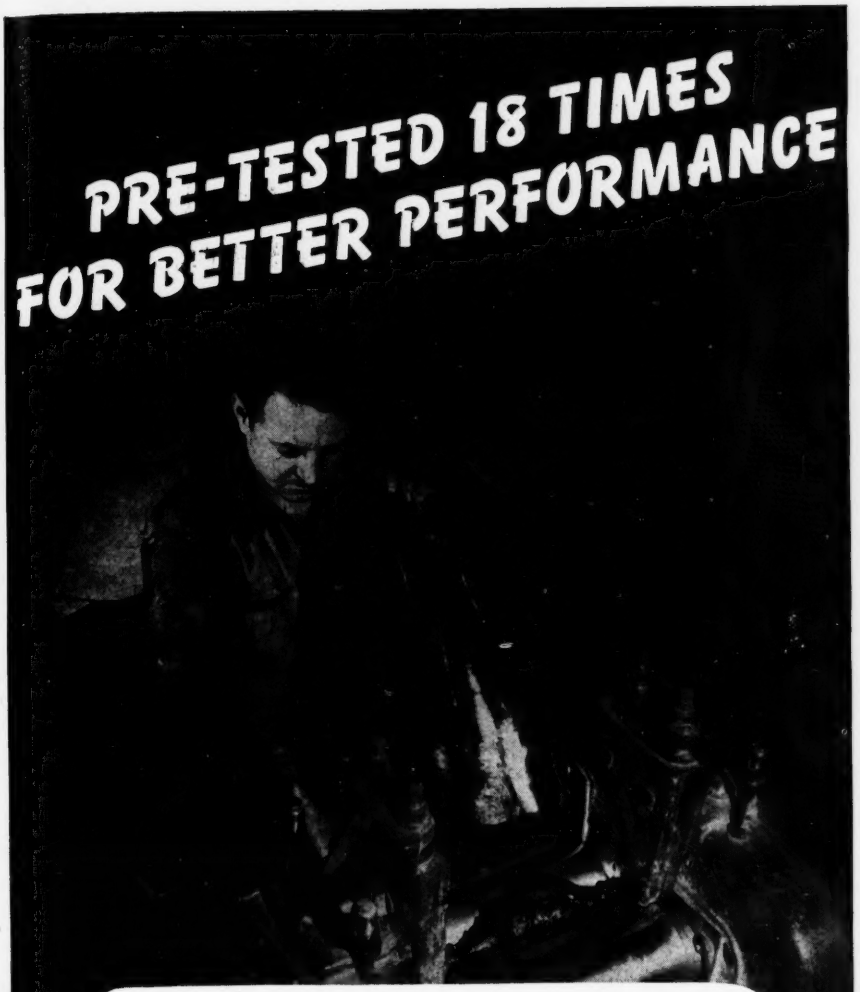
The first of these books was originally published in 1946 and there has been so much demand for it that now a second edition is required. The second book, just issued on Gas Turbine Construction, forms a good companion volume to the first.

In reviewing The Modern Gas Turbine, in POWER PLANT ENGINEERING, January, 1947, page 122, we said that Mr. Sawyer has injected some unity, coherence and emphasis into the discussion of the gas turbine that has been going on throughout the technical fields for the past four or five years. This book describes the operating principles and general construction of Houdry gas turbine units, the bombproof gas turbine power station at Neuchatel, Switzerland, various experimental turbines, a number of open and closed-circuit gas turbines under construction in Switzerland, as well as those being planned by Allis-Chalmers, Elliott, Westinghouse, General Electric and others in this country.

At the time both first and second editions were being written, the work of Yellott and the Locomotive Development Committee on the coal burning gas turbine had not progressed very far. At that time, we stated that the next step would be the preparation of a textbook or treatise expounding the new field of the gas turbine in terms of the fundamental sci-

(Continued on page 154)

PRE-TESTED 18 TIMES FOR BETTER PERFORMANCE



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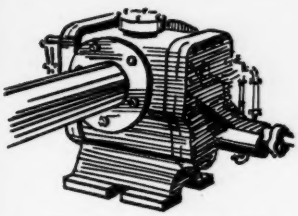

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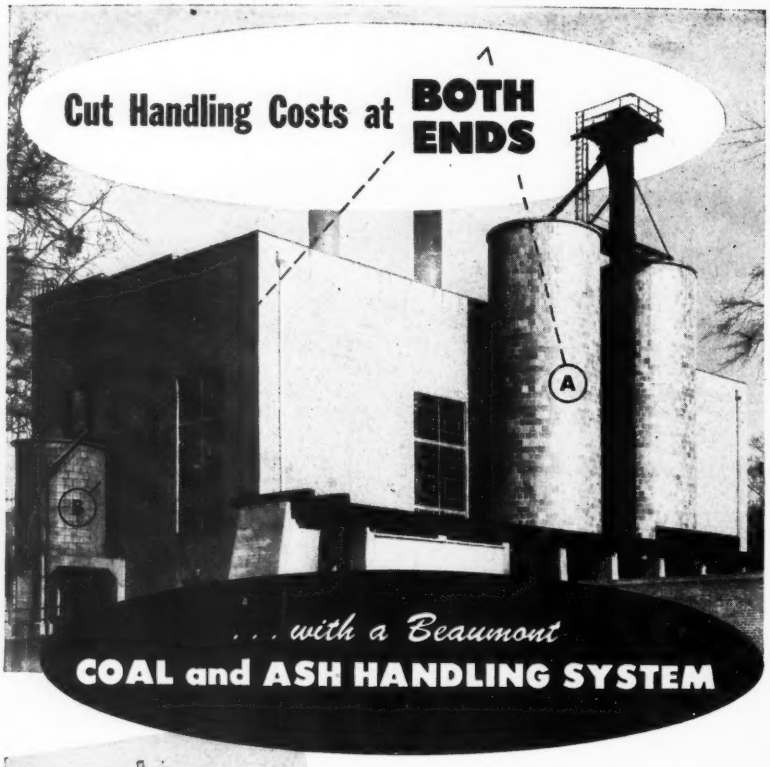
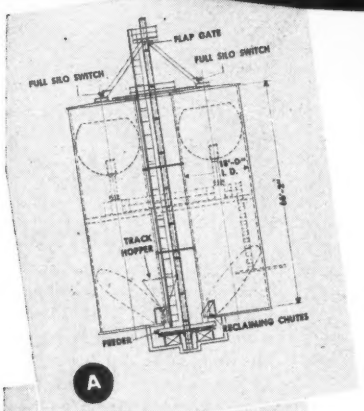
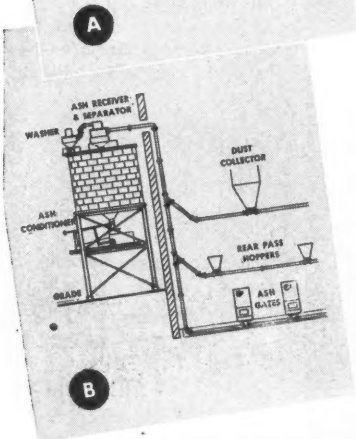
One well-known eastern refinery found the right answer for packing 4" stuffing boxes when it put Quaker #1675 Petro-pak to the test. Specially-designed for the petroleum industry, Petro-pak passed the test with flying colors . . . provided safe, leak-proof sealing action.







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PRINTED CIRCUIT TECHNIQUES

IN RESPONSE to an unprecedented demand for technical information on printing electronic circuits the National Bureau of Standards has just published the first comprehensive treatment of this subject entitled *Printed Circuit Techniques*, by Drs. Cledo Brunetti and R. W. Curtis. The booklet consists of 10 chapters totaling 43 large, two-column pages and is adequately illustrated with 21 halftones, 18 line cuts and five tables. NBS Circular 468, *Printed Circuit Techniques*, is now available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 25 cents per copy.

HELPFUL BULLETINS

(Continued from page 38)

and description of their operation. One spread is devoted to a typical compressor plant set-up, showing a photograph of a complete layout, including compressors, intake filter, piping, aftercooler, receivers, headers and control panel. A selection table for choosing the proper size aftercooler for specific compressor output is also included. Ingersoll-Rand.

46 **Combustion Unit**—A tandem combustion unit for combined gaseous and oil fuels is described in this supplement 6 to Bulletin No. 50. Shown is a drawing of the unit as part of a system, and two other installation drawings. Also included is a capacity data table and a listing of the utilities required at the burners. National Airoil Burner Co.

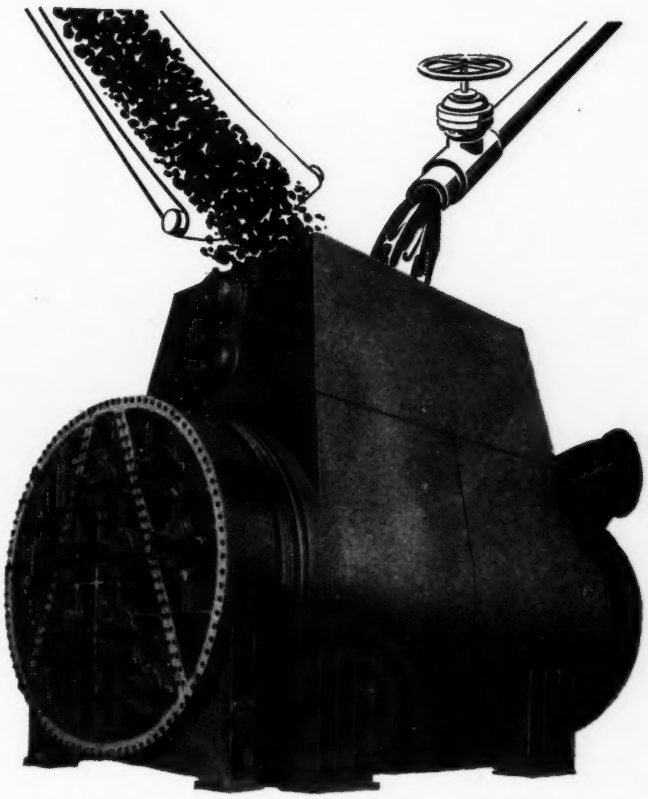
47 **Speed Drives**—This is an excellent 24-page bulletin describing a line of speed drives. Diagrams and subject matter show how the drives work. Typical installations are photographed. There are two pages of photographs showing the various features. An enlarged photo details how a motor is placed upon a machine. Other photographs present information on a number of manual and electric remote control drives. Also described is the manner in which the drives are inspected. Master Electric Co.

48 **Welding Fittings**—A line of stainless steel seamless welding fittings is described in Catalog S-309, 52 pages. A visual index shows how to locate the desired type fitting in the catalog. The first section of the catalog illustrates and describes a few of the steps in the making of the fittings. The remainder of the catalog is devoted to such engineering data as line drawings, photographs, and dimensional tables for the various fittings, in addition to a page listing dimensional tolerances of the fittings listed in the catalog and a table giving the standard stainless steel types and range of analyses. Pittsburgh Piping and Equipment Co.

49 **Steam Jet Ejectors**—A new well illustrated 36-page Catalog No. 1462 presents the theory and operating characteristics of steam jet ejectors for all classes of vacuum service, including single, two, three, four and five stage types. Non-condensing and condensing types, with barometric inter-and-after-condensers for vacuum requirements in chemical plants, food plants, sugar refineries, power plants, etc., are described in detail. Information regarding steam jet vacuum refrigeration for water cooling requirements of air conditioning and process applications is also presented. Saturated air and water vapor mixture curves showing the amount of air required to saturate one lb of dry air at various temperatures and abs. pressures, engineering data and formulae for determination of the capacity of an installation, a pressure, temperature, volume table for saturated steam, and tables for converting Centigrade to Fahrenheit, millimeters pressure to inches of Mercury, and microns to millimeters of inches, are included. C. H. Wheeler Mfg. Co.

50 **Water Heating**—Bulletins SM-4 and SM-5 contain invaluable information on a line of industrial water heaters. Diagrams, subject matter and photographs show how the water heater works. A typical problem is presented and answered. A table in each bulletin gives a list of ratings and specifications while another shows hot water requirements. A table in Bulletin FM-5 details the thermostatic valve capacities. Both bulletins feature a schematic layout of a steam mixed water heater. O'Brien Steam Specialty Co.

HOW MUCH FUEL DO YOUR CONDENSERS "BURN"?

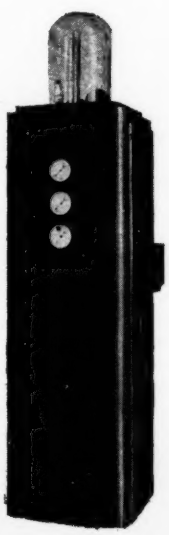


Sounds like a foolish question, doesn't it? Actually it isn't—here's why: Every fraction of an inch of condenser back-pressure uses up fuel which costs you money but gives you no return, so in effect that fuel is burned up in the condenser and goes to waste—a total, and often unnecessary, loss.

The loss is unnecessary because condenser back-pressure is the result of lowered heat transfer and most transfer difficulties are due to micro-biological slime deposits on water-side surfaces.

These deposits can be economically eliminated—as has been proved in hundreds of installations—by chlorination properly applied to the cooling-water circuit. And, in addition to fuel savings, you'll gain these extra advantages, too: reduced labor costs, lower cooling water pumpage expense and less equipment out-of-service time.

Whether you use fresh, salt or brackish water and regardless of the type of cooling-water system, W&T Engineers with over thirty years' experience in water treatment will be able to show you a job-engineered W&T De-Sliming System for your plant that can save you money—often enough to pay for itself in less than a year on fuel savings alone. Why not call for an engineering study? No obligation, of course.



CD 27

WALLACE & TIERNAN PRODUCTS, INC.

CHLORINE AND CHEMICAL CONTROL EQUIPMENT

Belleville 9, New Jersey • Represented in Principal Cities

CATALOG LIBRARY

This monthly list of the latest standard catalogs and bulletins is designed to aid the engineer in maintaining his permanent catalog file of engineering data. The items listed, unlike those under Helpful Bulletins, will appear each month except for additions and deletions dictated by space requirement or by the manufacturers issuing the bulletins. Use the Helpful Bulletins coupon in requesting these copies.

BOILERS

51 **Steam Generators**—Catalog almost completely devoted to cross-sectional drawings with accompanying listing of principal data of typical installations in rubber companies, steel works, sugar refineries, municipal plants, etc. Details of furnace water wall construction on inside back cover; 16 pages. Henry Vogt Machine Co., Inc.

52 **Double-Pass Boilers**—Bulletin R-M-1 (6th edition); illustrates and describes this line of riveted or welded double-pass steel firebox boiler. Three full pages of dimensions, ratings and other details including dimensioned line diagrams; 8 pages. The Brownell Co.

53 **Boilers, Burners, Accessories**—Bulletin GC-10; condensed catalog of regular products for stationary power plants. Each class of equipment summarized and illustrated with line drawings and photographs. Illustrations accompanied by brief descriptions; 12 pages. Combustion Engineering Co., Inc.

54 **Standardized Boilers**—Bulletin 746; 4 page bulletin presenting construction and operation information and ordering specifications for this company's Type M boilers. Bulletin illustrated, presents table of measurement and data. Springfield Boiler Co.

55 **Steam Generators**—Presents reason for high efficiency; shows brief case histories of plants. Results of tests by independent authorities and "Facts You Should Know About Steam Generating Units." Ratings, dimensions and other data presented. Springfield Boiler Co.

56 **Steam Generator**—Bulletin 119; company's Type S steam generator described and features of construction are pointed out. Folder well illustrated and dimensioned drawings and table of dimensions and sizes are given. Union Iron Works.

57 **Stirling Boilers**—Bulletin describing Type H Stirling boiler for low-head room use. Several specific installations of the unit are cited, dimensional data are given for various sizes and capacities of the units. The Babcock & Wilcox Co.

SLUDGE the Octopus
of FUEL OIL INEFFICIENCY
WASTE OF FUEL OIL
CLOGGED BURNER NOZZLES
CONGESTED FUEL LINES—RUST AND CORROSION
DIMINISHED STORAGE SPACE
IMPAIRED COMBUSTION
DETERIORATION OF TANK
• Combat Sludge . . . Increase
Production with NO-SLUDGE . . . the
Guaranteed Fuel Oil Treatment.
Write for full details

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WATER CONSULTANTS AND CHEMISTS FOR INDUSTRIAL AMERICA
11 WEST 42nd ST. · NEW YORK 18, N. Y.
Canadian Distributor: THOMAS ROBERTSON & CO., LTD.

PRIME MOVERS

58 **Axial Flow Impulse Turbine**—Bulletin S-107; six types described; data for estimates; applications types, casings; wheels and blades; shafts, nozzles and bearings; overspeed stop and other governor features; lubrication; 8 pages. The Terry Steam Turbine Co.

59 **Multi-Stage Turbine**—Bulletin SR-114; Casing, lagging, wheels and blades; shafts, nozzles, bearings; governors; speed changer or synchronizer; governor valve and steam strainer; lubrication; general; 10 pages. The Terry Steam Turbine Co.

60 **Turbines, Pumps, Products**—This 24-page catalog covers the company's complete line of products from steam turbines to flexible couplings. Every product is discussed from the design and operation angles and the discussion is heightened in interest by the inclusion of many excellent photographs. Other products discussed are helical gears, centrifugal pumps, multi-stage pumps, screw pumps, blowers, compressors and speed reducers. De Laval Steam Turbine Co.

61 **Turbine Cleaning Manual**—This 20-page bulletin covers the step-by-step solvent and manual cleaning of turbines from the inspection and preliminary cleaning to draining and final inspection. The cleaning and bearings and governor, installation of filter unit, circulation of cleaning solvent, and displacement of cleaning oil with new lubricating oil are steps which are covered briefly but clearly. Shell Oil Company, Inc.

62 **Steam Engines**—Bulletin No. 306; Engineering data; tabular material, descriptions; 8 pages. Troy Engine & Machine Co.

63 **Generating Sets**—Bulletin No. 108; General description, typical installations, engineering data tables, details of construction, completely illustrated; 24 pages. Troy Engine & Machine Co.

64 **Stationary Diesel Engines**—Dependability, adaptability of Diesel power described and applications pointed out. Its economical and simple design is stressed. Advantages of company's equipment brought out; exceptionally well illustrated; 24 pages. Enterprise Engine and Foundry Co.

65 **Steam Engines**—Bulletin 306 describes vertical steam engines. Full page table of engineering information on Types E and ST engines is presented as is a section on construction details of such parts as piston and rod, cross head, crank shaft, etc. Well illustrated. Troy Engine & Machine Co.

66 **Mechanical Drive Turbines**—Bulletin H-16 gives direction on selection of a unit and tabular material or general specifications and material specifications. Twenty one of the unit's features are pointed out and a large sectional drawing and a table of dimensions and a dimensioned line drawing also are shown. Elliott Co.

ELECTRICAL

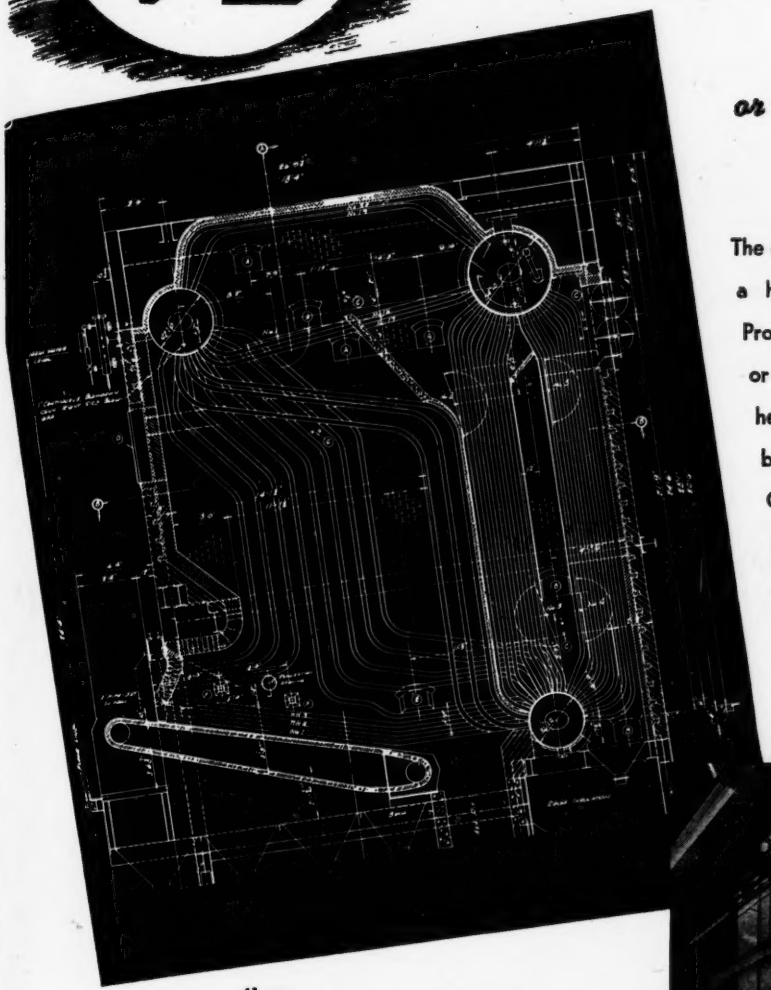
67 **Oil Circuit Breaker**—Bulletin 71B-6421 describes Unitop oil circuit breakers; ratings from 15 to 46 kv. 500,000

CLASS **VL**

Vogt

Steam Generating Units

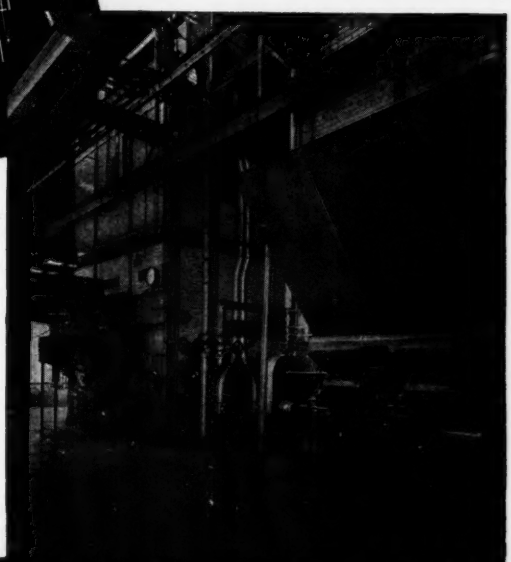
for POWER *or* PROCESSING LOADS, *and* HEATING



The design provides large furnace volume and a high ratio of radiant heating surface. Proper combustion is assured with any fuel or method of firing. Superheaters, air preheaters, economizers, water walls, and soot blowers can be readily incorporated. Vogt Class VL Steam generating units are giving satisfactory service in Hotels, Sugar Refineries, Steel Mills, Furniture Factories, Distilleries, Oil Refineries, and related industries. A bulletin showing typical installations will be sent upon request.

Above:
This 90,000 lbs. steam per hour unit, designed for 475 lbs. pressure, serves the Mansfield Tire & Rubber Co., Mansfield, Ohio.

Right:
Two 515 H.P. units installed in Brown-Forman Distillers Corporation, Louisville, Ky. Plant.



HENRY VOGT MACHINE CO. • 1000 W. Ormsby St., Louisville 10, Ky.
Branch Offices: New York, Philadelphia, Cleveland, Chicago, St. Louis, Dallas

to 1,500,000 kva interrupting capacity. Well illustrated. Allis-Chalmers Mfg. Co.

68 **Generating, Substation Equipment**—Bulletin 25B6150 titled "More Power to U.S.A." 32 pages; sketches coverage of the company's equipment from hydro and steam turbines to switchgear and circuit breakers. Unusually well illustrated. Allis-Chalmers Mfg. Co.

69 **Fuse Booklet**—16-page pocket size booklet tells of outstanding construction features of fuses—such as the renewable link and spring tension locking of links in circuit. Full-page wash drawings are used to emphasize features. Two pages of price and specification data are included. Ware Brothers.

70 **Electrical Precipitation**—Cottrell Process is described and three gas cleaning problems—recovery of valuable material, cleaning for subsequent use, and the elimination of a nuisance are covered. Research Corp.

AUXILIARIES, ACCESSORIES

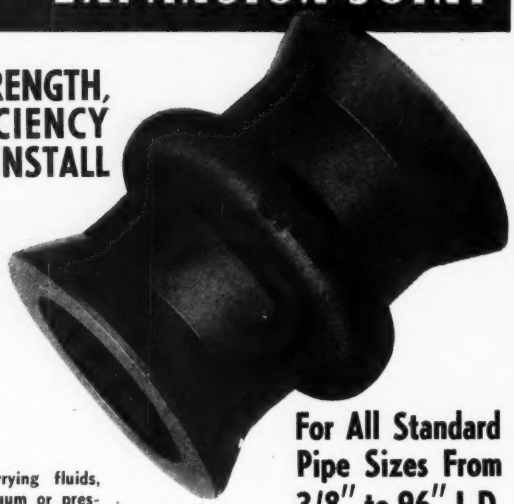
71 **Strainers and Separators**—Bulletin 46-50; describes complete line of company's strainers and separators. Dimensioned drawings and photographs; tables of sizes and complete description of applications, operation and design; 16 pages. American District Steam Co.

72 **Atomizing Deaerators**—Bulletin 4160; 3 color drawing illustrates description of principle of operation. Advantages of deaerators are described and illustrated; marine deaerators also covered; 20 pages. Cochrane Corp.

73 **Condensate Return System**—Description of operation and possible savings accompanied by line diagram and description of how "Jet-Loop" works; typical installation pictured and described. Drawings and text show proven results from experience of users, 2-page spread of drawings and table of dimensions; 16 pages. Cochrane Corp.

A REALLY *Modern* EXPANSION JOINT

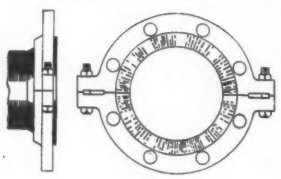
IMPROVED STRENGTH, SAFETY, EFFICIENCY ...EASIER TO INSTALL



Goodall Rubber Expansion Joints are based on a new simplified principle of operation and a patented construction which makes its application possible. All motion resulting from expansion, contraction and vibration takes place in center corrugation, size of which is determined by maximum movement required. Used on lines carrying fluids, steam, air, gases, under vacuum or pressure, at temperatures up to 250° F.

For All Standard Pipe Sizes From 3/8" to 96" I. D.

"FLANG-LOK" FLANGES ... For Quick, Easy Installation



Goodall Expansion Joints have ends shaped to accommodate "Flang-Lok" Flanges. These are designed to simplify installation and to provide a positive non-metallic seal by drawing the rubber or neoprene covered ends of the expansion units together. Furnished in steel or cast iron. Bolt holes are easily aligned by turning flange only. Magnitude of forces making seal is in direct proportion to stress applied to bolts when tightening.

Contact Our Nearest Branch for Details, or Send for New Folder

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THE GOODALL-WHITEHEAD COMPANIES

Philadelphia • Trenton • New York • Boston • Pittsburgh • Chicago • St. Paul • Los Angeles
San Francisco • Seattle • Salt Lake City • Houston • Factory: Trenton, N. J. • Est. 1870

74 **Low Pressure Evaporators**—Description of L. P. evaporators; types of evaporator plants, listing of advantages of L. P. submerged tube evaporators. Line diagrams illustrate principles brought out in descriptions. Typical installations are considered and analyzed; 12 pages. Condenser Service and Engineering Co., Inc.

75 **Power and Industrial Equipment**—Bulletin Q-12; describes and illustrates company's equipment for power and industrial use—steam turbines, motors, generators, feedwater heaters, turbo-chargers, steam jet ejectors, centrifugal blowers. Exceptionally well illustrated; 20 pages. Elliott Co.

76 **Heat Exchanger**—This new bulletin describes the company's Twin G-Fin Section; Bulletin 1614; section characterized as universal heat exchanger. Bulletin tabulates 21 features and corresponding advantages, describes design and construction. Installation views shown, field reports included; 16 pages. The Griscom-Russell Co.

77 **Evaporators**—Bulletin 364 describes, illustrates exporators for various capacities and pressures; contains sections of special interest to plant engineers and executives; includes explanation of functions of evaporators, benefits obtained by their use; different types of evaporating systems and their association with plant balance. 26 pages. The Griscom-Russell Co.

78 **Soot Blowers**—Bulletin F45; soot blowers in general are described. Description and operation of units, materials and specifications and other pertinent information is presented; tables of steam consumption, boiler efficiency, fuel saving chart; boiler cross-sections with blower locations indicated thereon and installation drawings and data are included; 10 pages. Marion Machine, Foundry & Supply Co.

79 **Water Heater Capacity Ratings**—14 tables are included in this ratings booklet showing capacity ratings per hour for temperature rises of from 20 deg (50 to 70 deg) up to and including ratings for a 150 F temperature rise (50 to 200 F). Table No. 15 presents the rate of flow of steam through pipes with steam from an initial gage pressure of one pound up to 150 psi. Marion Machine, Foundry and Supply Co.

80 **Open Heaters**—Publication 4091, 24 pages, covers three lines of open heaters for direct contact heating of boiler feed water and industrial process water. Characteristics of design and operating information and installation photos are presented. Cochrane Corp.

81 **Coal Weighing Scales**—Description; outstanding features, specifications, line drawings, photos; 4 pages. Beaumont Birch Co.

82 **Steam Specialties**—Collection of folders steam trap, air trap, reducing valves, classes E, B and H pump governors, automatic boiler feedwater controller; parts and units list prices; descriptions; illustrations; tables of capacities. The C. E. Squires Co.

83 **Deaeration**—Data book; No. N-15 gives reasons for and principles of deaeration; cold water deaeration; tabular drawing and chart material presented; well illustrated; 20 pages. Elliott Co.

84 **How to Choose a Steam Trap**—Trap selection, trap rating, trap capacity factors, individual trapping, determining lift; traps for unit heaters, pipe coils, fan system heating surfaces, steam jacketed kettles, autoclaves, laundry equipment, paper makers, etc.; installation, operation, maintenance, instructions; specifications and capacities, corrosive service; 42 pages. The V. D. Anderson Co.

WATER TREATMENT

85 **Index for Calcium Carbonate**—Reprint of paper by John W. Ryznar; tables and charts; 16 pages. National Aluminate Corp.

86 **Boiler Feedwater Q & A**—Bulletin 30; 102 questions and answers on various problems of boiler feedwater; 16 pages. National Aluminate Corp.

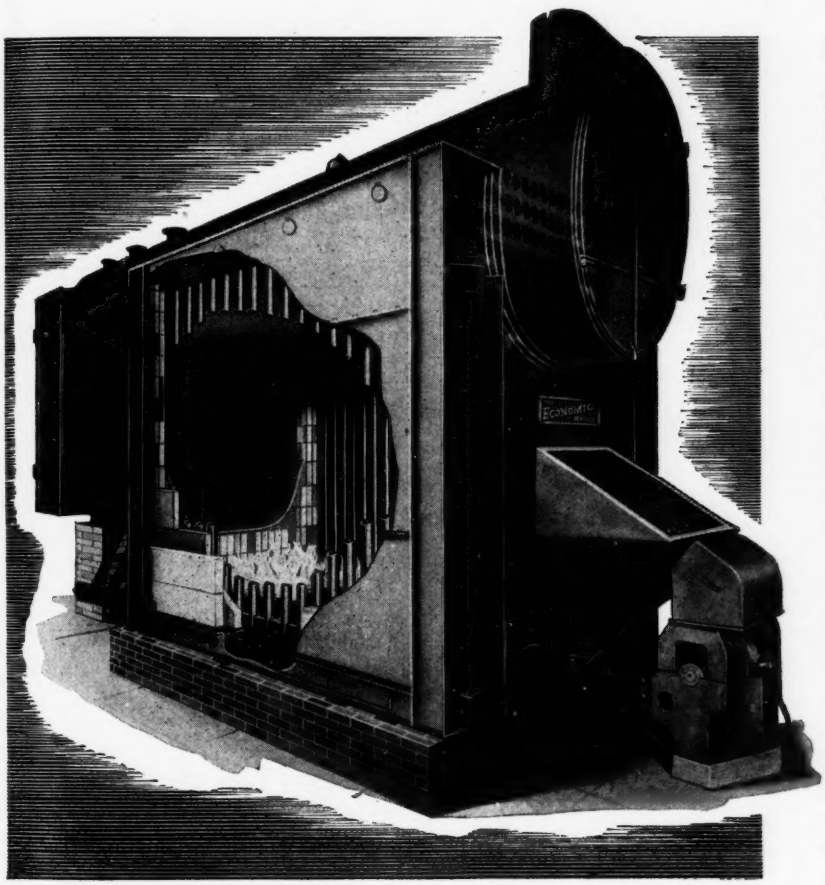
87 **Water Treatment**—Scale and corrosion control in potable water supply; reprinted paper presented by Hanlon, Steffen, Rohlich and Kessler; 12 pages. National Aluminate Corp.

88 **Water Conditioning Service**—"The 6 Fundamentals of Betz Water Conditioning Service" illustrates and describes how this company extends a supervisory service for boiler water conditioning. Booklet shows complete operation of these 6 steps; 16 pages. W. H. & L. D. Betz.

ERIE CITY

Provides Water-Cooled-Refractory in a Self-Contained Fire Tube Boiler

SIZES 50 TO 300 H.P.~



Side Walls of Erie City Water Wall Economics are made up of vertical 3" tubes, backed by 2" of refractory tile and 3" of high grade insulation. The whole is enclosed by a steel casing made up in panel sections. Cover plates provide easy access to the handhole plates opposite the circulator tubes in the upper headers and to the key caps in the lower headers. These key caps are arranged so that an angle expander can be used from the outside.

THE Erie City Standard Economic Self-Contained Boiler - Furnace Refractory Unit, used by thousands, has a "big brother"—the *water cooled* Economic. Side wall vertical circulator tubes, exposed to the fire, connected by squared seamless headers, backed by refractory, insulation and steel casing, serve a dual purpose. They provide greater steaming capacities while reducing refractory maintenance to the vanishing point.

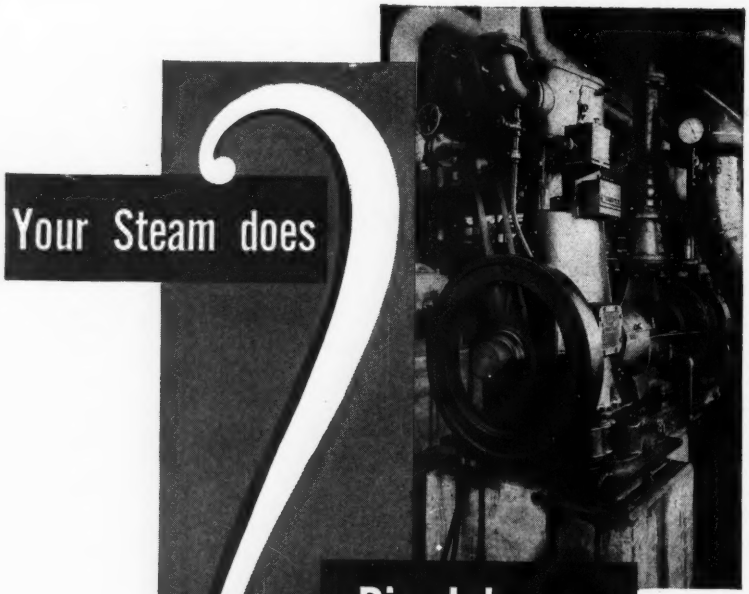
The Erie City *Water Wall* Economic Boiler greatly extends the range of economical operation previously possible with ordinary fire tube boilers. It is designed to get the most from any mechanical firing method. These *Water Wall* Economics can be shipped completely built-up in sizes to 300 H. P. Write for booklet that illustrates in detail this modern Self-Contained Fire Tube Boiler with side *Water Walls.*

COMPLETE STEAM POWER PLANT EQUIPMENT

ERIE CITY

Complete Steam Generators • Type C 3-Drum Boilers • Type VL 2-Drum Boilers • The "Economic" Boiler with or without Water Walls • Welded H. R. T. Boilers • Welded Steel Heating Boilers • Coal Pulverizers • Underfeed Stokers • Welded Pressure Vessels for the Process Industries.

ERIE CITY IRON WORKS • ERIE, PA *Since 1840*



Your Steam does 2 Big Jobs....

When a Troy-Engberg Engine is Used

With proper plant heat balance your steam may do two big jobs. If you generate steam for processing or heating a Troy-Engberg Steam Engine can produce By-Product Power at a very low cost. The same steam then yields power as well as heat units!

It's the simplest story in the plant. Steam is first passed through the engine — driving pumps, stokers, compressors, blowers or generators. Then the exhaust, with most of the original heat units still intact, is used for processing or heating. And for dependability nothing beats the standard counterflow steam engine . . . no interruptions from power failure.

TROY ENGINE & MACHINE COMPANY
(Established 1870)
2100 Railroad Avenue Troy, Pennsylvania

TROY-ENGBERG
STEAM ENGINES • GENERATING SETS • GENERATORS

89 **Water Softener**—Bulletin 607; benefits and economies of soft water; typical applications; how it works; types; design and features; backwash and brine rinse regulators; how to modernize present softener; aerators, degasitors, chemical feed systems, chemicals; 20 pages. Elgin Softener Corp.

90 **Softener Handbook**—Manual, semi- and full-automatic zeolite water softeners are covered in Bulletin 315. Water softener plant is discussed in the first section and operating cycles and plant supervision is next considered. The third section is "Selecting Manual or Automatic Equipment"; this is accompanied by a table of comparison data. Graver Tank & Mfg. Co., Inc.

91 **Hot Process Water Treatment**—Form 326 is a case study bulletin; covers results of an installation of the company's hot process equipment at Kankakee Ordnance Plant. System was designed to provide 60,000 gph of properly conditioned water, free from hardness, scale forming minerals and corrisive gases. Graver Tank & Mfg. Co., Inc.

92 **Water Treatment**—Control of Fouling Organisms in Fresh and Salt Water, by John G. Dobson. Life history of these organisms; method of control. Wallace & Tiernan Products, Inc.

93 **Industrial Water Treatment**—Microbiological Control of and Through Industrial Waters; spot summaries of improvement of process efficiency and product quality of proper sterilization. Wallace and Tiernan Products, Inc.

94 **Cooling Water Treatment**—Bulletin 10 is an engineering information sheet on treatment of cooling water. A brief explanation of reaction in heat exchangers, condensers, etc., is presented. Bulletin describes necessary treatments. Liquid Conditioning Corp.

95 **Condenser Water Treatment**—Chlorination of Condenser Cooling Water, by R. B. Martin; important consideration in chemical treatment of cooling water circuits. Wallace & Tiernan Products, Inc.

96 **Clarifying and Softening Water**—Eight-page catalog "Reactivator for Clarifying and Softening Water by Upward Sludge Filtration." First part of the booklet tells how the reactivator works and how the sludge blanket is kept in control so as not to flow out with the clarified water. Line diagrams illustrate the principle of operation. Graver Tank & Mfg. Co., Inc.

97 **Feed Water Treatment**—This 4-page folder tells how the company's engineering applied to boiler feed water problems can result in savings. It tells of the different procedures and presents diagrams of equipment arrangement. Typical installations in dairy, cosmetic, aircraft, laundry, and other plants are pictured. Illinois Water Treatment Co.

98 **Chemical Feeding and Proportioning**—Bulletins 1100 and 1713A; use of adjustable chemical feeder for water treating, sewage, chemical processes, petroleum; plan and sectional diagrams; descriptions; photos; general specifications; 2-page table of capacity schedules; list of chemicals handled; accessories; drawings of boiler water conditioning systems; 5-page description of method of automatic intermittent feed of conditioning chemicals direct to the boilers; 20 pages. Proportioneers, Inc.

99 **Automatic Proportioning** — Bulletin 1200, 28 pages. Handy reference book containing wealth of information on automatic flow responsive equipment and methods in continuous process operation. Photos of equipment and installation are supplemented by many flow diagrams and detail drawings. Complicated subject made exceptionally clear and understandable by careful arrangement and two-color diagrams. Proportioneers, Inc.

100 **Water Conditioning Instruction Booklet**—Bulletin 28X6385 was written especially for guidance of power plant operators. It touches upon importance of feedwater control, care of test procedures. Handy reference tables given as aid to reporting results. Allis-Chalmers Mfg. Co.

101 **Complete Water Conditioning Service**—This 4-page bulletin describes this company's complete water conditioning service—analysis, design fabrication, installation and maintenance of water treating equipment. Typical installations are pictured and brief sketches of the men behind the service are given. Graver Tank & Mfg. Co., Inc.

COATINGS, TREATMENT

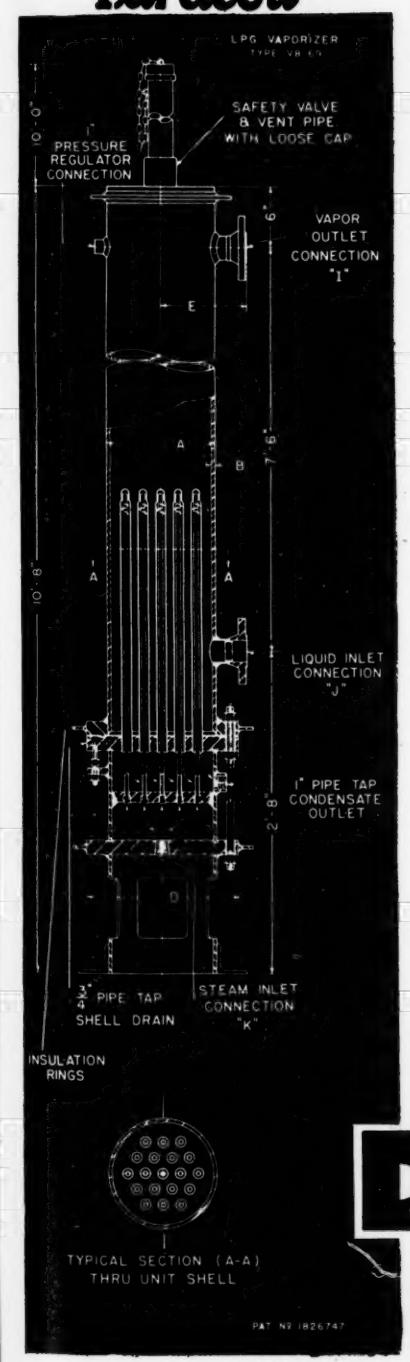
102 **Protective Coatings**—Four-page folder 844-246 describes Bitumastic Hi-

"HOT PLATE" LPG STEAM VAPORIZER

TRADE MARK REGISTERED

for Medium and High Capacity L. P. G. SYSTEMS

Paracoil


LPG VAPORIZER
TYPE VR-6S
SAFETY VALVE & VENT PIPE WITH LOOSE CAP
1" PRESSURE REGULATOR CONNECTION
VAPOR OUTLET CONNECTION "I"
LIQUID INLET CONNECTION "J"
1" PIPE TAP CONDENSATE OUTLET
¾" PIPE TAP SHELL DRAIN
STEAM INLET CONNECTION "K"
INSULATION RINGS
TYPICAL SECTION (A-A) THRU UNIT SHELL
PAT. NO. 1826747

When plant site weather conditions are sufficiently severe as to indicate the use of a Vaporizer with your L.P.G. system, the Paracoil "Hot-Plate" Steam Vaporizer offers operating advantages possessed by no other unit.

FEATURES

- **PATENTED "HOT-PLATE" NON-FREEZING CONDENSATE DRAINAGE SYSTEM.**
- **Installed Above Ground—Entirely Outside the Storage Tank. Can be used with Any Type of L.P. Gas.**
- **High Output Capacity—Up to 1000 Gallons Per Hour Per Unit.**
- **SUPERHEATING OF L.P. GAS IN VAPOR PHASE IMPOSSIBLE.**
- **Fully Automatic in Operation.**
- **No Moving Parts—Nothing to Get Out of Order.**
- **Fitted with Approved Type Relief Valve.**
- **No Vaporizer Flames Used—Operates on Low Pressure or Exhaust Steam.**
- **Easy Access to Heating Surface for Inspection.**

DATA

SIZE NO.	CAPACITY GALS./HR.	A	B	D	E	K	I	J	SAFETY VALVE SIZE	WEIGHT LBS.
H-24S	125	10¾	.365	15⅛	9½	1	2	2	1½	770
K-24S	200	12¾	.375	17¼	10½	1	2	2	1½	1100
L-24S	300	14	.375	18½	11¼	1	2	2	1½	1260
N-24S	500	16	.375	20½	12½	1½	2	2	1½	1590
T-24S	1000	22	.375	26½	16	2	2	2	2½	2690

All Dimensions in Inches — Dwg. 1-14568-B

SPECIFICATIONS

MATERIAL

Outer Shell	—Seamless Steel Pipe
Outer Vaporizing Tubes	—⅞" OD 16 BWG Seamless Steel
Inner Steam Conveyor Tubes	—½" OD x 20 BWG Seamless Aluminum
Tube Sheets and Flanges	—Rolled Steel Plate
Steam and Condensate Channels	—Welded Steel
Supporting Base	—Welded Steel

DESIGN

A.S.M.E. Code, Par. U-69
N.B.F.U. Pamphlet No. 58, Spec. B.10.i

Working Pressure:	Shell	250 PSIG	(Liquid Vapor Side)
	Tubes	200 PSIG	(Steam Side)
Test Pressure:	Shell	500 PSIG	Hydrostatic
	Tubes	400 PSIG	Hydrostatic

Liquid Inlet Connection — 300 Lb. Design
Vapor Outlet Connection — 300 Lb. Design

ASME CODE CONSTRUCTION—HARTFORD INSPECTED
MEETS ALL N.B.F.U. REGULATIONS
WRITE FOR ENGINEERING DATA AND PRICES

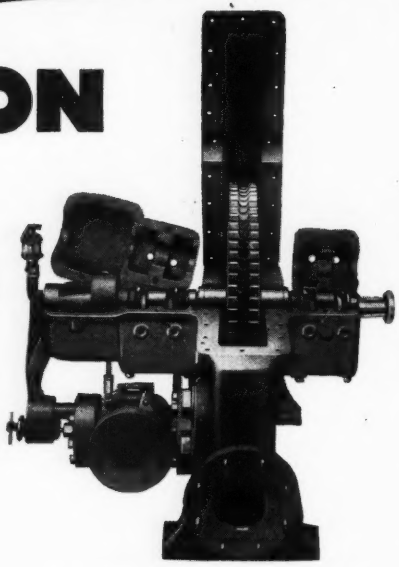
DAVIS ENGINEERING CORPORATION

1063 East Grand Street, Elizabeth 4, New Jersey

30 Rockefeller Plaza, New York 20, N. Y.

PROMPT DELIVERY

WHITON STEAM TURBINES WITH SOLID STEEL ROTORS



Whiton Steam Turbines are available in four standard sizes covering a range of from 5 to 1200 HP in single stage types. Speeds vary from 1200 rpm or slower up to any practical speeds. Whiton features horizontal split casings with inlet and exhaust connections located in lower half, providing easy accessibility. Semi-circular buckets are milled into the rim of the solid steel rotor for greater operating efficiency and longer life.

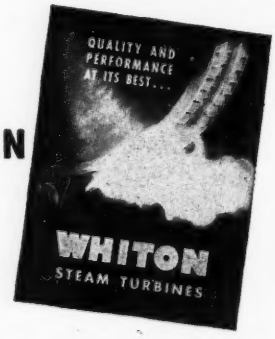
Shipments of 5 to 6 weeks can be made on Standard Frames.

Recent changes have taken place at Whiton which have involved slight alteration in name; more noticeable changes in personnel and service, but no change in the high quality and assured performance of Whiton products. Inquiries involving the application of steam and power supply will be given prompt attention by the Whiton Engineering Service Division. We welcome the opportunity to be of service.

Write for New

STEAM TURBINE BULLETIN

New fully illustrated folder includes engineering and design data, drawings and dimensions. Write for a copy today.



Steam Turbines *Centering Machines* • *Chucks* • *Gear Cutting Machines*

THE WHITON MACHINE COMPANY

234 HOWARD STREET

NEW LONDON, CONN., U. S. A.

SINCE 1856

Heat Gray, a specialized industrial protective coating which is said to resist corrosion and temperatures up to 1200 F. The folder is in two colors and contains several photographs of equipment on which Bitumastic has been applied. It also gives a list of uses for the material and a chart giving its characteristics. Walles Dove-Hermiston Corp.

103 Flue Cleaner—The company's soot and fire scale removing compound is described in this 6-page folder. Results obtained from the use of this compound are described in the first part of the folder and then a list of things which the company guarantees the material will accomplish are listed. Tables of dosage are presented and another table shows losses due to soot and fire scale. Dominion Chemical Co., Inc.

104 Boiler Water Treatment—Eight-page bulletin describes system of complete boiler water treatment. Group of photographs show how investigation is made at boiler plant to gather necessary data and how technical department studies water analysis and plant data. Discussion of "how complete boiler water treatment functions." E. F. Drew & Co., Inc.

105 Fuel Oil Treatment—Four-page bulletin presents engineering data on a fuel oil treatment for prevention and correction of unsatisfactory conditions in storing, pumping, heating, burning of industrial fuel oil. Two drawings show when treatment is used. Discussed is the problem of sludge. Application of treatment is explained. E. F. Drew & Co., Inc.

106 Fuel Oil Treatment—Several bulletins have recently been announced by this company describing completely the application and effect of its fuel oil treatment compound and Diesel engine solvents. Wilcolene Mfg. Co.

HEATING, COOLING

107 Cooling, Heating, Air Conditioning—Collection of bulletins; installation, design, construction data, capacity ranges, condensed physical data, numerous photos of installations, full page color diagrams of flow of air, compressed air, water, water spray, etc. Niagara Blower Co.

108 Insulating Cement—Ease of application, efficiency; ease of maintenance application recommendations; heat loss calculations, 4 pages. Baldwin Hill Co.

109 Water-Cooled Stoker—Catalog W; drawings of installations; features; furnace views; 8 pages. American Engineering Co.

110 Spreader Stoker—Installation views; features of various parts; cross-sectional view of furnace with installation; listed features; 8 pages. American Engineering Co.

INSULATION STOKERS

111 Coal Reference Bulletin—"600 Post-war Installations" of power plants in the United States are covered in Bulletin 10. Trend in new central stations and industrial plants is sketched and outstanding features of design of best stations described briefly. A table presents an industry classification of power plants by types of firing. Fairmont Coal Bureau.

112 Pneumatic Spreader Stoker—Three-fold booklet on the inner pages of which there are 30 spirally-bound vertical pages which fold back to tell the story of the stoker, installation, features, construction, principles, engineering, types and models, typical installations; well illustrated; 33 pages. Iron Fireman Mfg. Co.

113 Poweram Stoker—Bulletin 7121; essentials of successful stoker; fuel control, fuel convoying, fan capacity, controls, installation; illustrations; 18 pages. Iron Fireman Mfg. Co.

114 Coal Reference Bulletin—Bulletin 8, Underfeed Stoker Firing. Bulletin covers factors involved in selection of multiple retort stokers, principles, design data and drawings of typical installations; 6 pages. Fairmont Coal Bureau.

115 Stoker Firing Operation—Single Retort Underfeed Stoker Firing is the subject of Bulletin No. 9 issued by this Bureau. It is a complete analysis of the advantages of the single retort stoker in the smaller plants. Types of this stoker are described and principles of operation are outlined. Fairmont Coal Bureau.

OIL, GAS BURNERS

116 Wide Range Oil Burning System—Bulletin 109; how the system operates; control, drawings; 4 pages. Peabody Engineering Corp.

117 Oil Burners—Bulletin 108. Two types of oil burners, A and H; air registers, oil atomizers, drawings; 4 pages. Peabody Engineering Corp.

REPUBLIC VALVES REPUBLIC

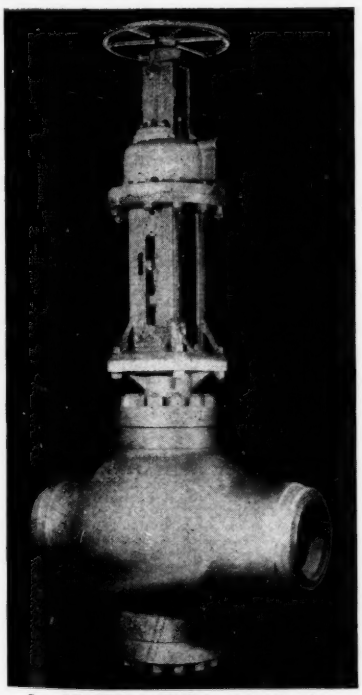
REGULATING—PRESSURE REDUCING—SHUTOFF

CYLINDER OPERATED

Republic cylinder operated valves are of the gradual opening, high lift, double seated type. They are hydraulicly operated to assure smooth performance at any speed regardless of size, static pressure or pressure reduction. These valves are available in sizes from 3" to 24", with or without hand operating wheel. Due to compact design, a regulator may be mounted directly on the valve.

HAND OPERATED

Republic hand operated valves, in sizes from 1" to 8", are built to 900 lb. and 1500 lb. pressure standards. Sizes up to 2" are also available for 600 lb. pressure. They are of the single seated type, have a one piece valve stem, and seat rings that are Stellite surfaced. On the larger sizes the gear reduction head is built with ball or roller bearings and precision ground gears for minimum friction and back lash.



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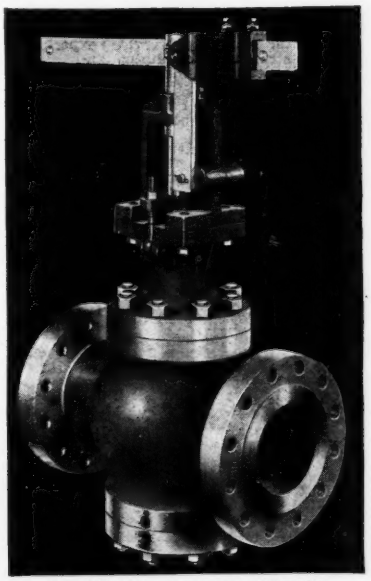
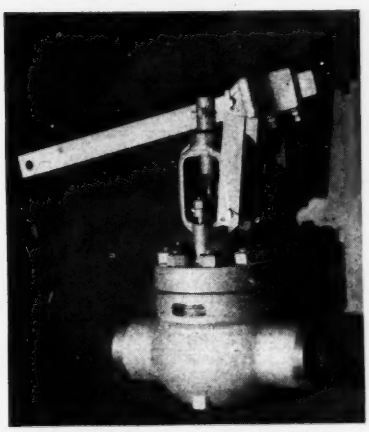


Republic 6 in. lever operated valve



Republic 2 in. lever operated valve

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Republic double seated lever operated valves are available in sizes from 3" to 16" for low pressure applications and in sizes up to 6" for 1500 lb. applications. They are ideal for air actuation with long stroke cylinders. The lever mechanism is of sturdy construction capable of taking full strain of power cylinder.

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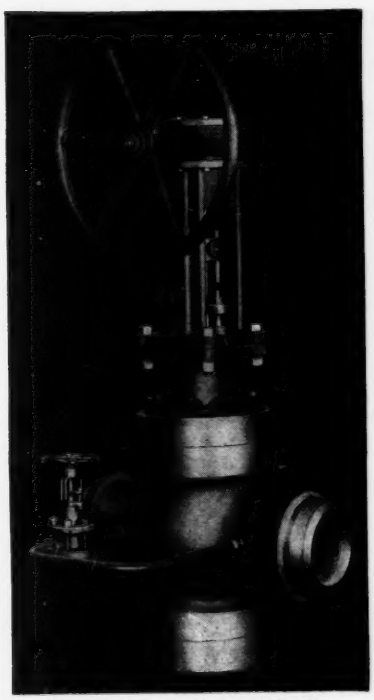

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118 **Oil Burner**—Wide-range Y-jet steam atomizing oil burner is described. Construction, application and advantages of unit are shown and bulletin tells how burner has established excellent standards of performance. The Babcock & Wilcox Co.

OIL, LUBRICATION

119 **Lubrication Recommendations**—Special oils for Diesels and heavy-duty gasoline engines; facts about oil; tables of recommended oils for various models; 18 pages. Standard Oil Company of California.

120 **Cutting Fluids**—Facts about cutting fluids, machine tool operations; fundamentals of cutting; how to apply; metallic cutting tools; tabular material; shop practices; 50 pages. Standard Oil Company of California.

121 **Diesel Operation**—Relation of fuels and lubricants to the operating efficiency of the diesel engine; diesel fundamentals; maintenance; lubrication and fuels; supercharging; selection and classification of fuels; fuel injection maintenance; improving cleanliness; tabular material, charts, formulas; 114 pages. The Texas Co.

122 **Engineers Report on Oil**—Engine tests, laboratory tests, effects on engines, bearing corrosion, actual service data, filter clogging, service experience; well illustrated with photos and charts; 42 pages. Standard Oil Company of California.

123 **Lubricants Service Handbook**—28 pages in this booklet on lubricants and their application. The development of the lubricant, its features and advantages and the manner in which it meets various operating conditions take up the fore part of the booklet. "Recommendations" section where the manufacturer tells just what grease or oil should be used according to speeds, temperatures, pressures and general service conditions is given. Fiske Brothers Refining Co.

124 **Oil Products for Industry**—Cutting oil, processing oils, general lubricants, refrigeration oils, Diesel oils, solvents, greases and waxes are among the petroleum products for industry which are described in this 4-page folder. The various grades of each oil are analyzed and the reasons why they are fitted to each particular job are given. Sun Oil Co.

POWER TRANSMISSION

125 **Speed Reduction, Increase Gear**—Bulletin S-130; description; gear cases; gear and pinion; bearings; lubrication; drawings and photos; 8 pages. The Terry Steam Turbine Co.

126 **Flexible Couplings**—Bulletin 57; two pages of drawings and tables of ratings for company's flexible couplings. Installations are shown and features of the various types are discussed; 20 pages. John Waldron Corp.

127 **Fluid Drives**—Bulletin 8019 tells about automatic fluid speed drives for 3600 rpm boiler feed pumps. Cutaway illustration and curve shows operational improvement and construction and operating features are pointed out. American Blower Corp.

VALVES

128 **Regulating Valve**—Bulletin 1-A; valve data book, description, dimensions and lists of parts; typical installations, rated capacities; prices; 52 pages. Atlas Valve Co.

129 **Pressure Reducing Valve**—Bulletin 1-C; sectional drawings, list prices, dimensions and weights; operation and adjustments; capacities for steam and air; 12 pages. Atlas Valve Co.

130 **General Service Valve**—Bulletin E-150; valves for blow-off; fire protection, soot blower lines, acids, process, etc.; description; exploded views; features; dimensions, weights and list price tables; parts and parts lists; 14 pages. Everlasting Valve Co.

131 **Valve**—Bulletin E-100; for boiler room service; photos; descriptions, parts; features; pressure rating indexes; size, shipping weight and price tables; ordering information; 30 pages. Everlasting Valve Co.

132 **Diaphragm Motor Valve**—24 pages. Covers Why and How of unit's design. Materials specifications given as are two pages of engineering information and charts. Kieley & Mueller, Inc.

133 **Butterfly Valves**—Bulletin 77 describes butterfly valves especially de-

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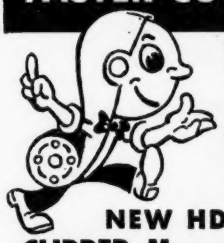

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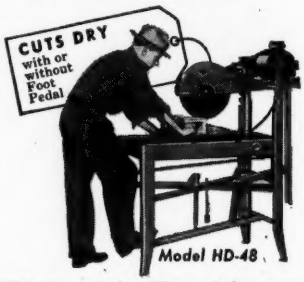

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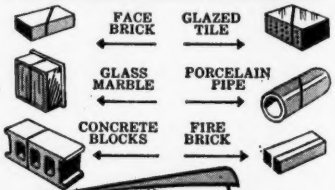

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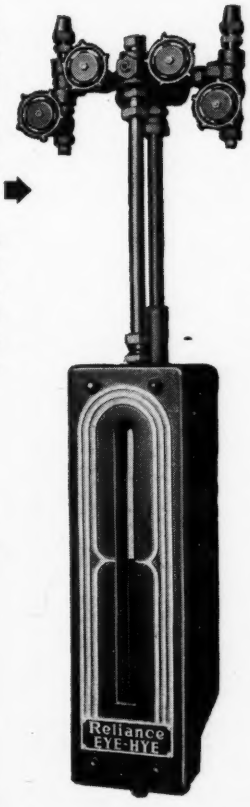

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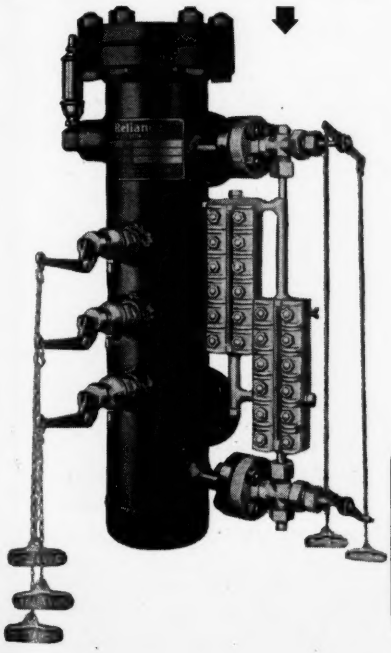

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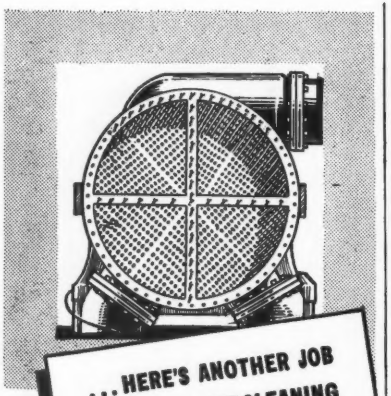

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signed for diaphragm motor valve operation. Characteristics and construction features described; a chart shows flow characteristics taken from actual tests. Sectional and detailed drawings of valves are used to list various parts. Fisher Governor Co.

134 **Control Valves**—Catalog 546 covers line of control valves for air, gas, oil, steam or water up to 500 psi. Applications are described and line drawings, detailed engineering information and material classifications are presented. W. H. Nicholson & Co.

135 **Air Release Valve**—Operation, construction and essential requirements of air release valves described in Bulletin 140. Discusses dangers of air in pipe lines and solution to problem. Simplex Valve & Meter Co.

136 **Self-Cleaning Strainers**—Bulletin 465 presents tables of screen specifications and total free hole area to facilitate correct screen selection. Tables of dimensions of cast iron, cast bronze, cast steel and stainless steel strainers. Charts, illustrations and photos complete bulletin. Leslie Co.

MAINTENANCE

137 **Maintenance Jobs**—This guide tells how better to perform commonly occurring power plant maintenance and cleaning operations. Illustrated manual gives specific material and method recommendations for handling cleaning, degreasing, descaling, derusting, paint stripping, etc. Booklet is completely indexed and reference is made by colored type strips on edge of the pages; 22 pages. Oakite Products, Inc.

138 **Condenser Tube Inserts**—Description of Flowrites; illustrated, accompanied by report of tests on Flowrites made by M.I.T. Tables and charts of test results are presented; description of how to install inserts given; 8 pages. Condenser Service & Engineering Co., Inc.

139 **Building Maintenance Guide**—"Over the Rough Spots," provides answers to more than 100 problems inherent in maintenance and construction of all types of buildings. Its 48 pages are packed with information about floors, walls, foundations, roofs, etc. Special information of interest to railroads, mines, utilities and water works. Stonhard Co.

CONTROLS, METERS

140 **Damper Regulators**—Bulletin 4-A; for low pressure heating, medium pressure power and high pressure power boilers; what they do; how to specify; typical installations (drawings); adjustments; list prices; technical descriptions and parts lists; 20 pages. Atlas Valve Co.

141 **Recording Flow Meter**—Bulletin 349; what it does, features, chart of rated capacity; construction and operation; installation drawings, tables of capacity; photos; 8 pages. Builders-Providence, Inc.

142 **Propeller-Type Meter**—Bulletin 350A; for main-line metering; applications, description, installation, materials of construction; features; table of capacity, shipping weights; specifications, drawings; 4 pages. Builders-Providence, Inc.

143 **Centralized Combustion Control**—Bulletin 43-605; application to various types fuels and burning equipment; controller, measuring elements, pilot device, power units, etc.; 24 pages. The Hays Corp.

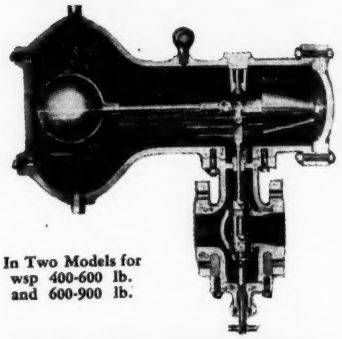
144 **Combustion Meters**—Bulletin 44-550; reasons why it is accurate, dependable, simple, rugged, easy to install, easy to maintain, speedy, easy to understand; well illustrated by explanatory diagrams; 16 pages. The Hays Corp.

145 **Remote Feed Water Control**—Bulletin 471 describes Type P regulator for remote control of boiler feed water. Construction features of unit are described and complete hook-ups of the regulator with different types of valves are shown. Complete descriptions of hook-ups are given. Northern Equipment Co.

146 **Liquid Level Indicators**—Bulletin WG-1822, 16 pages, describes liquid level indicators for boilers, heaters and other vessels in industrial and central stations. Construction and operating details are covered. Installation instructions and specification information given. Yarnall-Waring Co.

147 **Electronic Instruments**—Bulletin 231 describes recently-developed line of electronic instruments for temperature, flow and other factors. Measuring circuits are described and diagrams presented;

STETS



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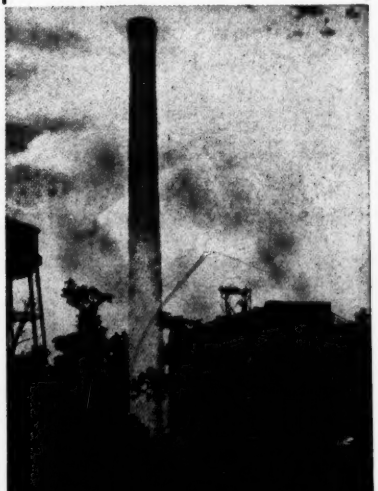

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these diagrams include resistance bridge, potentiometer circuits, impedance bridge and calculating circuits. Bailey Meter Co.

148 **Feed Water Regulation**—Bulletin 429B, 12 pages, covers the company's automatic flow regulator for controlling boiler feed water. Photos of installations, charts and studies of boiler water level control under various conditions of pressure and information on operation and construction of the unit are given. Specifications are listed. Northern Equipment Co.

149 **Engineering Monographs**—Series of eight on automatic combustion control: 1. How Close Can Steam Pressure Be controlled? 2. Why Operate Automatic Combustion Control from Changes in Steam Pressure? 3. Adapting to the Characteristics of Underfed Stokers. 4. Adapting to Spreader Type Stokers. 5. Adapting to Chain or Traveling Grate Stokers. 6. Adapting to the Characteristics of Pulverizers. 7. Adapting to the Characteristics of Oil Burners. 8. Adapting to the Characteristics of Gas Burners; total 37 pages. The Hays Corp.

150 **Draft**—Bulletin 46-472; what draft is; where it is found; how it is measured; what the draft gage tells, where to measure draft and pressure in steam plant; where to connect draft gages; how to install; drawings; 20 pages. The Hays Corp.

151 **Flue Gas Analyzer**—Bulletin 45-668; principle of operation; construction features; technique; models and prices; Burrettes—classification and uses (table); what flue gas analysis tells us; 16 pages. The Hays Corp.

152 **Indicating, Control Systems**—What they are, what they can do; Bulletin 14B6641. Description of how transmitter, receiver and indicator of systems are constructed, how they work, their advantages and specifications. Illustrated with photographs, diagrams, charts; 12 pages. Allis-Chalmers Mfg. Co.

153 **Water Gages**—Condensed catalog, Bulletin E, of company's complete line of water gages. Each model illustrated and accompanying table gives sizing information; 8 pages. Ernst Water Column & Gage Co.

154 **Stainless Steel Bellows**—Bulletin SSB-46; contains diagrammatic cross-section views and up-to-date information concerning the use of these bellows as equalizers, compensators, expansion joints, flexible connectors for flow control, vapor and steam traps, thermostatic instruments, etc. Completely illustrated; 12 pages. Chicago Metal Hose Corp.

155 **Pitot Equipment**—Three section Bulletin 50; gives complete details of the use of Pitot tubes and rods, instructions in the use of the company's portable Pitot recorder, together with theory, formulae, notations and curves. Completely indexed; 20 pages. Simplex Valve & Meter Co.

156 **Temperature Regulators**—Bulletin 7-A; six types; descriptions; list prices, tabular material, photos; list of parts; typical installation drawings; tables for finding sizes of control valves required to heat given quantity of water; 16 pages. Atlas Valve Co.

157 **Draft, Excess Air and CO_2**—Bulletin 39-341; discussion of the relation of these elements to the installation and servicing of bituminous and anthracite stokers by Arnold Soller; 12 pages. The Hays Corp.

158 **Liquid Level Controllers**—Bulletin A-100 is a 4-page catalog describing this company's Types G and D liquid level regulators. Excellent cross-sectional views of the units are presented and their operational and constructional features are described. Dimensions, capacities and shipping weights are presented. Stets Company.

159 **Boiler Feed Control**—Bulletin 463, 16 pages, describes boiler feed control systems at Westover, Greenidge and Jennison Stations of N. Y. State Electric and Gas. Corp. Completely illustrated with photos and line drawings. Tables of significant data included, Northern Equipment Co.

160 **Water Level Control**—"Controlling Water Level on Combustion Engineering Type VU Boiler" is title of Bulletin 455. These four pages present photos and chart reproductions and tell the details of the company's control equipment on this particular type of boiler. Northern Equipment Co.

161 **Water Level Control**—Bulletin 459, 8 pages, description of water level control installation at Wyman-Gordon Co. Good illustrations show details of installation. Table of significant data given. Northern Equipment Co.

162 **Boiler Water Level Control**—Bulletin 467 and 465, 8 pages each, describe,

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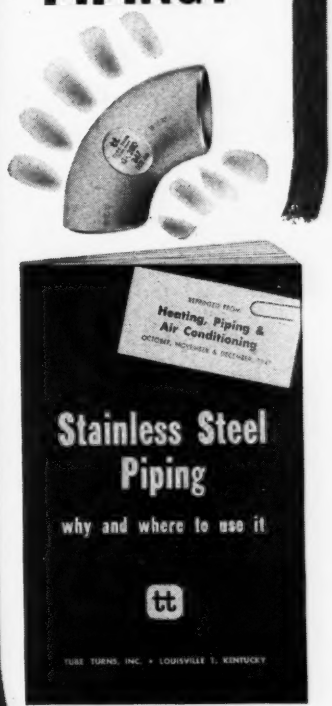

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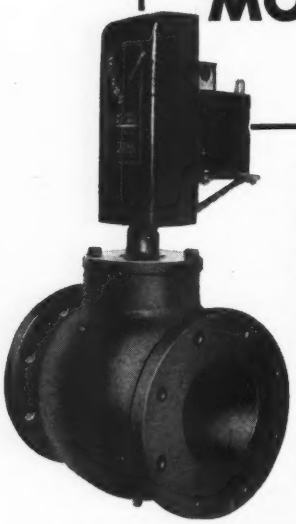

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A complete line of expanders for tubes 2" and up in various gauges and for tube sheet thicknesses from ½" up. Compactly designed for use in limited space and to pass through small handholds. They provide automatic self feed with rolling and flaring in one operation. Tapered rolls insure parallel expansion for tightly rolled tubes through the full thickness of heavy drum walls or thick tube sheets.

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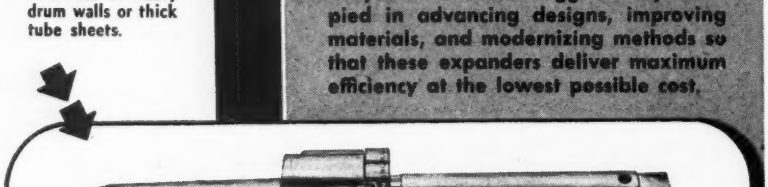
... Backed by a reputation for jobs well done!

Check the reputation of DUDGEON tools on the job—ask the man who uses them! Double check too, what we mean when we say "each tool is designed by and for men who know what good tools can do to cut costs and "up" job quality. Do this and you'll find that DUDGEON'S 97 years have been aggressively occupied in advancing designs, improving materials, and modernizing methods so that these expanders deliver maximum efficiency at the lowest possible cost.



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respectively, control installations at Buzzard Point plant and West Reading Station. Both give exceptionally detailed reports of the installation complete with tables, photos and drawings. Northern Equipment Co.

PACKING GASKETS

163 **Metal Packings**—Bulletin filled with information on line of metal packings for industrial use. Understandable line drawings accompany descriptions. Packing rings, wiper rings and piston rings also are described and illustrated. France Packing Co.

FITTINGS

164 **Welding Fittings**—Allowable working pressures; power, oil, district heating, refrigeration, gas and air piping; 14 tables and directions for use; 18 pages. Tube Turns, Inc.

165 **Welding Fittings**—Volumetric capacities, 2 pages of formulas for computation of capacities; 6 pages of tables; 12 pages in book. Tube Turns, Inc.

166 **Unions**—Complete line of malleable iron unions and convenience unions; illustrations, descriptions, size and list prices; descriptions of materials and workmanship; 24 pages. Jefferson Union Co.

167 **Welding Fittings**—Bulletin 47-1 covers stainless steel welding fittings ... 90 deg elbows, 45 deg elbows, 180 deg returns, lap joint stub ends, tees, caps, reducers. Specifications for each type are presented and tables give complete dimensional data. Information on welding of stainless steel is given. Midwest Piping & Supply Co., Inc.

PUMPS

168 **Horizontal Duplex Piston Pumps**—Bulletin 230-1; specifications, steam end, liquid end; capacity tables for pressure service, light pressure service; dimensions, drawings, tables; 4 pages. Warren Steam Pump Co., Inc.

169 **Steam Heat Vacuum Pumps**—Bulletin 226-1; specifications, drawings, general information, tables of sizes and capacities; 4 pages. Warren Steam Pump Co., Inc.

170 **Hydraulic Pressure Pump**—Bulletin 238; specifications, sectional photos, important features; full page table of capacity sizes, pipe sizes, pressure; 4 pages. Warren Steam Pump Co., Inc.

171 **Screw Pumps**—Recommended uses; advantages; tables of capacities and sizes; charts of test results; dimensioned drawings; suctions and discharge, packing box sizes, shipping weights tables; specifications; installation and maintenance; theoretical horsepowers; viscosity classifications; 18 pages. Sier-Bath Gear & Pump Co., Inc.

172 **Centrifugal Pumps**—Booklet describes basic action of centrifugal pumps, tells of the science of centrifugal action and the physics of pumping. Performance curves are presented. Descriptions of the company's self-priming centrifugal pumps are given and how they operate is explained. Typical use of the units are pointed out and installation and operation explained; 20 pages. Marlow Pumps.

173 **Centrifugal Pumps**—Bulletin 240, 6-page folder describing single stage, double suction. Type DBL centrifugal pump. Features of the pump resulting from its construction and engineering; a sectional view which is used to point out other advantages of the unit. Tables of metal specifications and capacity ratings in gallons are also given. Warren Steam Pump Co., Inc.

174 **Multi-Stage Pumps**—Bulletin 241 describes 4 and 6 stage Type TM pumps. Cross-sectional illustrations and tables of specifications are given. Dimensioned drawings and tables of dimensions accompany copy describing unit's construction and advantages. Warren Steam Pump Co., Inc.

175 **Close-Coupled Pumps**—Close-coupled pumps, called Compac-units, are described in Bulletin 242. This 8-page bulletin presents clear and understandable cross-sectional photos of the units and

uses these to point out construction and operation features. A full-page "Composite Rating Table" presents rating information at various heads for 9 different models of pumps. Warren Steam Pump Co., Inc.

176 **Compressors, Vacuum Pumps**—Bulletin C-5; 16 pages. Describes complete details of construction including illustrative material such as photographs of parts of the units and drawings of detailed structural parts. Tables present size and capacity information. Chart of typical characteristics is given. Fuller Co.

177 **Pedestal Type Pumps**—Listed in tabular form are heads and capacities of these units, also given is a Pump, Motor, Drive table. Operating advantages are listed and illustrated and features of construction are outlined. Allis-Chalmers Mfg. Co.

178 **Materials Handling Pump**—Catalog 547 describes all late developments in the "Hydroseal" pump. Line drawings and colored illustrations picture improvements in construction and tables show performance based on clear water. "Calculating the Pump Required," is a highly useful section of the bulletin. The Allen-Sherman-Hoff Co.

MISCELLANEOUS

179 **Floor Resurfacing**—This recently-published folder describes the methods of use of the company's heavy-duty resurfacer for use on floors, traffic aisles and loading platforms. It contains a concise, clear description of the properties, methods of application and advantages of the resurfacer and is of interest to everyone who has problems in the maintenance and repair of concrete floors. Stonhard Company.

180 **Electric Tools**—Bulletin 464; covers complete line of portable electric tools for construction and briefly describes such tools as electric hammers, drills, chisels, vibrating tools, accessories, screw drivers, etc. Prices are given. Syntron Co.

181 **Refractory Concrete**—"Lumnite for Refractory Concrete"; basic information on materials and methods used in making refractory concrete. Illustrations show application of concrete in construction of furnaces, coke ovens, etc. Lumnite Division, Universal Atlas Cement Co.

182 **Gas Purger for Refrigeration System**—Bulletin 160; tells how to cut power costs and raise condenser capacity by proper purging of non-condensible gases. Tables of ammonia properties, advantages, and complete illustrated material; 8 pages. Armstrong Machine Works.

183 **Grinding Wheels**—Grinding wheels of various abrasives are illustrated and list prices presented; tables of sizes in inches are accompanied by photographs and line drawings of these various wheels. Grinding wheel dressers with list prices are shown; 32 pages. Norton Co.

184 **Weldments**—Bulletin SP106 tells about the services of this company's weldry and the weldments turned out therein. The products of this weldry are shown and the text points out how flexible the method is. Graver Tank & Mfg. Co., Inc.

185 **Drop Forged Flanges**—Manufacturing processes; physical characteristics; full-page tables of illustrations, dimensions, weights and prices. Space provided for future insertions. Phoenix Mfg. Co.

186 **Vapor Cleaning Unit**—Latest equipment for steam detergent cleaning described in Form 6327R. Features of simple operation, control and delivery outlined by means of pictures. Engineering specifications and operating data given. Oakite Products, Inc.

187 **All-Purpose Electric Tool**—Electric impact tool which, using standard attachments, will apply and remove nuts, drill, ream, tap, drive and remove screws and studs, extract broken cap screws and studs, run wire brushes, do hole saw work, drill brick and masonry and drive wood augers. Photos show machine in operation on many jobs; description of tool given. Ingersoll-Rand.

188 **High Side Floats**—Bulletin 178 describes inverted bucket high side floats for discharging liquid refrigerant to the low side of refrigerating systems. Five stages of operation are shown in drawings. Armstrong Machine Works.

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RESISTANT TO TEMPERATURE VARIATION

Pressure: 0 to 250 lbs. without change of valve or seat. Length: 18" to 40". 2 types: thermostatic, continuous flow.

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Entirely automatic; only one moving part. Adjustable valve for passing condensate at any desired temperature. Low cost, making unit trapping practical. Usually installed without support. Also a complete line of weight and piston operated traps for steam, air, gasoline, pressures to 1500 lbs; thermostatic steam traps, pressures to 225 lbs. Catalog 444 or see Sweet's.

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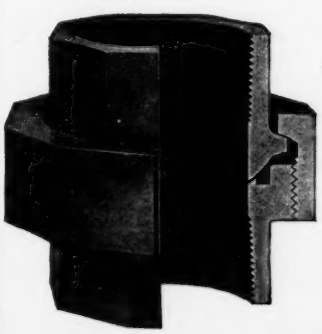

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It is cut from seamless drawn tubing—free from all casting defects—sound and uniform always! It cannot be dislodged by a pipe end screwed in too far.

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with these EXCLUSIVE FEATURES

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- Renewable Disc and Seat
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- Real Pump Protection
- Silent in Operation
- Insurance Against Damaging Water Hammer
- Built of Material to Meet Requirements of Any Service
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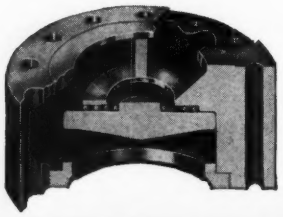

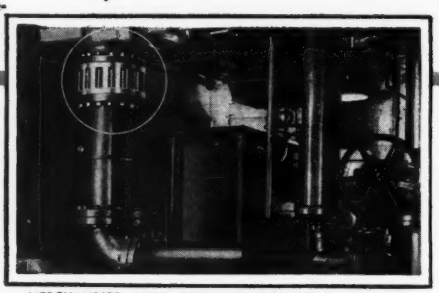

Rugged, simple and compact, it is easily-installed between flanges and can be readily removed for inspection. The Valve Seat and Disc are renewable and the valve can be reseated without special tools. The WILLIAMS-HAGER SILENT CHECK VALVE is built of carefully selected materials to very close tolerances. It is subjected to four inspections and very exacting tests before shipment.

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NEW ENGINEERING BOOKS

(Continued from page 138)

ences of engineering. This work has been started by the now famous series, "The Gas Turbine Power Plant," by John I. Yellott, published throughout 1947 in POWER PLANT ENGINEERING, later to be issued in book form by John Wiley & Sons.

Now with his second book on gas turbine construction, Mr. Sawyer carries on the fine work he has started. Since his first book was written there has been a tremendous development in this field. Today gas turbines are under construction by several American manufacturers to fill orders for several types of service. Hence this book helps keep engineers abreast of the rapidly-changing picture.

The book begins with a detailed discussion of the construction of the heavy gas turbine equipment that may be used in marine or locomotive service. After a brief review of the current situation, the author gives detailed operating experience with the Houdry gas turbines, based on the reports of Sun Oil Co., previously summarized in this and other magazines. These include method of operation, discussion of details of combuster, compressor and turbine, details of roller and thrust bearing, lubrication, glands, and governors.

Following this are detailed operating instructions for the Neuchatel 4000-kw gas turbine plant; then come details of gas turbine locomotive construction.

Chapter VI gives details of the use and fabrication of the high temperature materials used in the Elliott gas turbine unit, and Chapter VII discusses in detail the construction of closed-cycle gas turbine units such as proposed by Esher Wyss.

Part II of the book takes up the turbo-superchargers produced for internal combustion engines by a number of American companies. Part III discusses the aircraft gas turbine equipment of many American and British companies. It was the development of the materials and methods for these superchargers in British airplanes during the war that has so tremendously accelerated the current gas turbine work. The British simply had to develop these details in order to build airplanes that could defeat those of the Germans. In doing this, they have discovered a great many things about metals and principles of combustion that are useful not only in the aircraft field but that are being applied as well in the field of the stationary gas turbine.

The whole gas turbine field is expanding with the most unbelievable rapidity at the present time. This latest book on Gas Turbine Construction by Mr. Sawyer is a valuable contribution to the understanding of just what is going on.

Elementary Nuclear Theory, by H. A. Bethe; first edition, 148 pages, illustrated; 5⅝ by 8⅝ in., cloth; published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y.; price $2.50.

This book by Dr. Bethe, who has been a professor of physics at Cornell University since 1935, was written to give scientists and students a clear understanding of the fundamental theory of nuclear forces, the chief problem of nuclear physics. This book is not a textbook. It is an introduction to nuclear theory based on Dr. Bethe's lectures to engineers and scientists of the General Electric Company who are not specialists in nuclear physics. Dr. Bethe is well qualified to write such a book. Before joining Cornell faculty he was a lecturer in physics at the University of Manchester and Bristol in England. He began his studies of physics in Germany where he received his PhD from Munich in 1928. In this book he treats the subject entirely from an empirical point of view. He gives a fair analysis of beta disintegration as a well developed and fundamental aspect of nuclear theory. There is also a detailed

discussion of the properties of the deuteron. Purely theoretical considerations particularly the meson theory are dealt with only briefly because they are not yet in a form which permits useful prediction. Dr. Bethe explains the available evidence on nuclear forces on terms of the behavior of the simplest nuclear systems. He merely outlines the theory of compound nuclei and omits the theory of the fission process because they are very special aspects of nuclear physics.

Industrial Management, by William R. Spriegel and Richard H. Lansburgh; fourth edition; 656 pages; 6 by 9¼ in.; illustrated, cloth binding; published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, 1947; price $5.00.

The fourth edition by Professor William R. Spriegel, Head of the Department of Industrial Management at Northwestern University, offers a thorough discussion of the subject, including a presentation of the recent developments in the field. In addition to a new chapter on maintenance, more than 125 new illustrations have been added.

Throughout the book the author has attempted to show the relationships and interdependence of the various major departments of a business. The policies and principles of successful management and the devices required to carry them out are pointed out. Business relationships are treated with the thought that faith must be created in modern business—faith of the management in the employee and faith of the employee in the management.

The material is well arranged. Selections include: fundamental considerations; organization structure; the plant and equipment; motion and time study; wage payment; buying, selling and transportation; material and production control; and industrial relations.

"AT AN ILLINOIS PLANT, a Cochrane Steam Purifier and a Cochrane Discharger were put into operation. Our Chicago office reports that on one occasion, while severe priming was occuring, the operator as well as the plant engineer and several other men working about the plant, were greatly concerned lest slugs of water should reach either of the 400 rpm uniflow engines. The latter, however, continued to run sweetly although 6 in. of water (which might mean anything between 4000 and 6000 lbs) went out of the gage glass so quickly that the men had no idea of the duration of the priming."

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575 KVA SKINNER UNAFLOW ENGINE GENERATOR UNITS

3—750 H.P. Skinner unaflow engines, each directly connected to 575 KVA Westinghouse 220-volt, 3-phase, 60-cycle, 150-RPM alternating current generator, with 15-KW "V" BELT-DRIVEN EXCITERS.

Complete switchboard control apparatus, with switchboard-operated variable speed synchronizing devices and automatic voltage regulators.

ALSO AVAILABLE:

3—surface condensers with motor-driven circulating pumps.

3—250-HP low-pressure condensing steam turbines with auxiliaries.

This plant is one of the most modern medium-size steam power plants on the West Coast. It is complete in every detail.

The units were installed in 1935 and furnished complete power service for the building and presses of the Los Angeles Times. The plant has always been well maintained and is being removed from the Times Building now only because it is too small to furnish power for the building which is being enlarged to double capacity.

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(See illustrated advertisement in January issue of this magazine)

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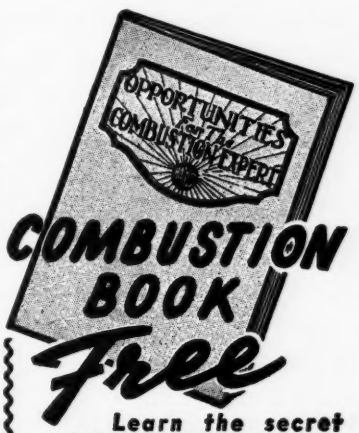

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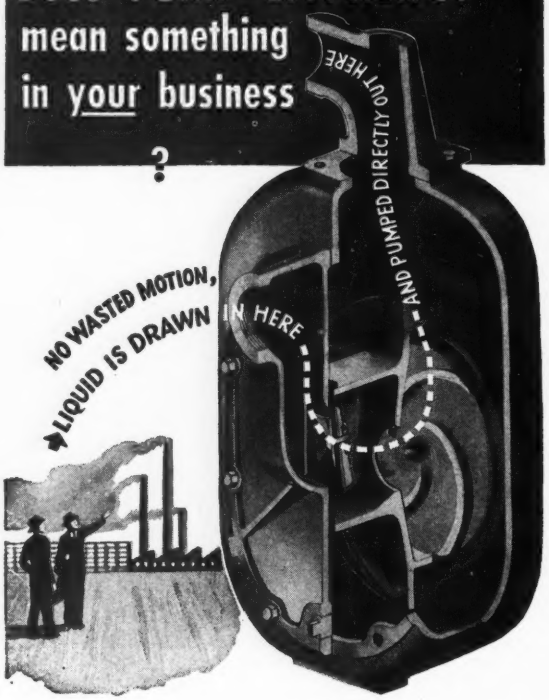

Production has been improved in many plants through these outstanding features of Marlow Self-Priming Centrifugal Pumps. Check them — then write for Bulletin EL 47 for full details. Marlow Pumps, 547 Greenwood Ave., Ridgewood, N. J.

1. Positive automatic priming. No need for gravity flow to pump.
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3. Pumps many liquids: clear, gritty, heavy, volatile.
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5. For continuous or intermittent service. Primes itself whenever necessary.
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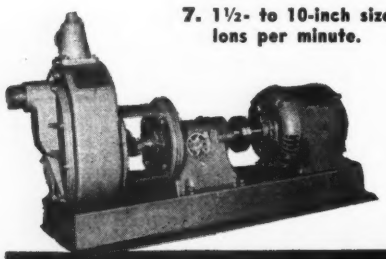
7. 1½- to 10-inch sizes. 15 to 3500 gallons per minute.



MARLOW PUMPS
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POWER PLANT Construction News

Ill., Carlyle—City Council, City Hall, plans extensions and improvements in municipal steam-electric power plant, with installation of a new 3000-kw turbine-generating unit and auxiliary equipment. Cost estimated about $350,000. Proposed to carry out work in 1948.

Iowa, Humboldt—Corn Belt Power Cooperative, Inc., Humboldt, has plans under way for new steam-electric generating station on site at or near Humboldt, to be equipped for initial capacity of 15,000-kw. Financing in amount of $5,300,000 has been arranged through Federal aid for this and line construction, power substations and other operating facilities.

Iowa, Keosauqua—Town Council has been authorized at recent election to arrange bond issue of $220,000, proceeds to be used for a municipal light and power plant. It is understood that Diesel engine-generators will be used. Engineer will be engaged soon to prepare plans.

Me., Augusta—Central Maine Power Co., Augusta, is arranging fund of about $9,500,000 for expansion and improvements in properties during 1948, including generating stations, power substations, transmission and distribution lines. Increased generating capacity will be provided.

Md., Baltimore—Consolidated Gas & Electric Co., Lexington Bldg., is arranging a 1948 development and improvement program to cost approximately $50,000,000. Project will include beginning of work on new addition to Westport generating station for extensions in steam and electric departments, with installation of new 60,000-kw turbine-generator, high-pressure boilers and accessory equipment; completion of expansion now in progress at Riverside plant, where increased capacity will be provided; new power substations, transmission and distribution lines, and other operating facilities.

Mass., Boston—American Sugar Refining Co., 47 Granite St., has preliminary plans for new cane sugar refinery on waterfront property on Atlantic Ave., comprising a number of buildings. Electric power equipment will be installed. A power plant will be built. Entire project reported to cost close to $18,000,000. It is understood that work will begin in 1948. Main offices are at 120 Wall St., New York, N. Y.

Mich., Jackson—Consumers Power Co., has authorized fund of $40,681,600 for expansion and improvements in plants and system during 1948. Of this amount, approximately $17,800,000 will be used for construction, enlargement and betterments in generating stations, including new B. C. Cobb power plant at Muskegon, Mich., now in course of construction and scheduled to be ready for service in September, with installation including two 60,000-kw turbine-generator units. Power substations and transmission lines for period noted are estimated to cost about $6,700,000.

Minn., St. Cloud—State Dept. of Administration, State Capitol, St. Paul, Minn., P. T. Peterson, director of purchases, has plans in progress for new boiler plant at State Teachers' College, St. Cloud, for central-heating service. No estimate of cost announced. Frank W. Jackson, American National Bank Bldg., St. Cloud, Minn., is engineer.

Miss., Greenwood—Town Council plans extensions and improvements in municipal steam-electric generating station, with installation of equipment for increased capacity. Cost estimated about $250,000. Bond issue in that amount has been authorized for project.

Mo., Springfield—Bd. of Public Utilities, City Hall, E. C. Rice, president, has plans under way for new municipal power plant, estimated to cost close to $6,000,000. Burns & McDonnell Engineering Co., Bannister Rd. and Troost St., Kansas City, Mo., is consulting engineer.

N. Y., Nyack—Rockland Light & Power Co., Nyack, has plans maturing for superstructure for new steam-electric generating station at Tompkins Cove, and will begin construction early in 1948. Burns & Roe, Inc., 233 Broadway, New York, N. Y., is consulting engineer.

N. C., Kinston—Town Council plans extensions and improvements in municipal steam-electric generating station, with installation of additional equipment for large increased output. Bond issue of $1,175,000 has been authorized for work. Proposed to carry out project soon.

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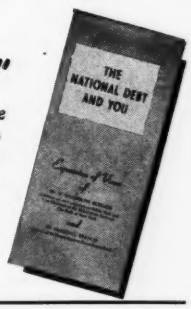
a 12-page pocket-size brochure, expresses the views of W. Randolph Burgess, Vice Chairman of the Board of the National City Bank of New York, and Clarence Francis, Chairman of the Board, General Foods Corporation. Request your copy from the Treasury Department's State Director, Savings Bonds Division.



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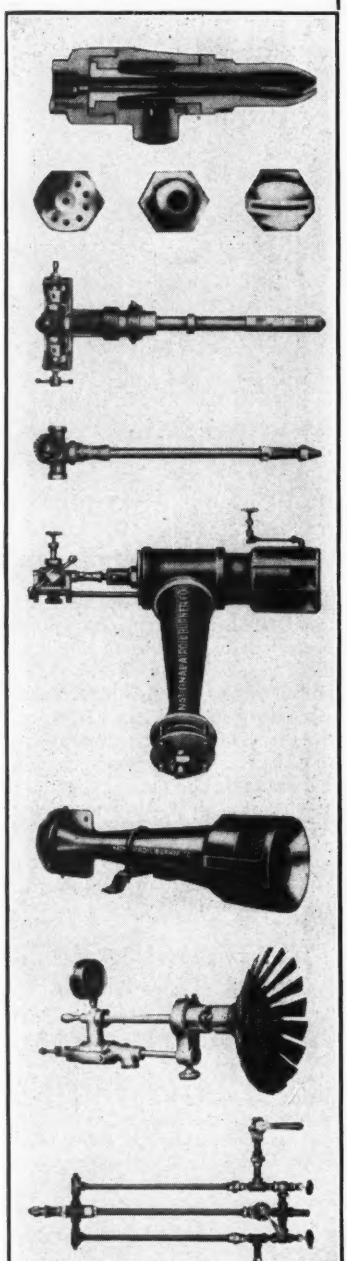
the *RIGHT* BURNER for *YOUR* JOB



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COMBINATION GAS AND OIL BURNER
— the "AIROCOOL" Gas Burner in combination with a TYPE "SAR" Oil Burner.

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(Of venturi type) assures low turndown without burnback.

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with multi-vane type air diffuser to give a positive swirl to entering combustion air.

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INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT

N. C., Washington—Town Council has plans under way for expansion and improvements in municipal steam-electric power plant. Additional equipment will be installed for increased capacity. Cost about $700,000. Bond issue in that amount has been authorized.

Ohio, Cleveland—Cleveland Electric Illuminating Co., 75 Public Sq., Cleveland, has authorized plans for extensions in Lake Shore generating station, including installation of a new turbine-generator unit and auxiliary equipment. Cost estimated about $8,300,000. This will be part of 1948 expansion and improvement program of company.

Ohio, Cleveland—Water Dept., City Hall, is considering preliminary plans for new water-treatment plant on Clague Rd., Westlake Village, equipped for large capacity for municipal water system. Cost estimated about $6,000,000. John C. Wenrich, City Hall, is city engineer, in charge.

Okla., Enid—State Board of Affairs, State Capitol, Oklahoma City, Okla., has plans under way for new boiler house for central-heating service at Northern Oklahoma State Hospital, Enid. Cost reported over $250,000, with boilers and auxiliary equipment. C. L. Monott, 1915 North Indiana St., Enid, is engineer.

Okla., Pawhuska—Municipal Light and Water Dept., has preliminary plans under way for extensions and improvements in municipal oil engine-operated power plant, with installation of new Diesel engine-generator unit and auxiliary equipment. Cost estimated about $200,000, of which approximately $150,000 will be provided by a proposed bond issue. V. V. Long & Co., Colcord Bldg., Oklahoma City, Okla., are consulting engineers.

Pa., Latrobe—West Penn Power Co., Pittsburgh, Pa., plans new automatic power substation for switching service in Derry Township, vicinity of Latrobe, estimated to cost about $180,000.

Pa., Lewistown—American Viscose Corp., has approved plans for expansion and improvements in steam-electric generating station at local rayon mill, with installation of new equipment and replacements in present apparatus to increase rating from 15,000 to 21,000-kw. Work is scheduled to begin early in 1948.

Pa., Philadelphia—Dept. of Property and Supplies, State Capitol, Harrisburg, Pa., has preliminary plans under way for new power plant at Byberry State Hospital, Philadelphia, estimated to cost over $2,000,000, with equipment. It is understood that work is scheduled to be carried out in 1948.

Pa., Philadelphia—John B. Stetson Co., Fifth St. and Montgomery Ave., men's hats, plans expansion and improvements in power plant at factory, including installation of additional equipment and replacement of present worn-out apparatus. Project will be carried out during 1948 and is reported to cost in excess of $600,000.

R. I., Newport—Public Works Dept., Naval Training Station, Newport, has plans in preparation for extensions and improvements in power plant at local station, with installation of equipment for increased output. Cost reported about $240,000. Capt. A. J. Fay, Naval Air Base, Newport, is engineer.

Texas, Lubbock—City Council plans new municipal electric light and power plant, estimated to cost about $2,000,000, with equipment, supplementing present municipal oil engine-operated station. It is understod that work will be placed under way early in 1948. Bond issue has been authorized in amount noted. Homer A. Hunter, Lubbock, is engineer.

Texas, Trinidad—Texas Power & Light Co., Dallas, Tex., has plans maturing for expansion in steam-electric generating station at Trinidad, with installation of new 63,000-kw turbine-generator, high-pressure boilers and auxiliary equipment. This will be part of extension and improvement program of company in 1948, which will also include installation of a 12,500-kw turbine-generator at plant at Waco, Tex., and new 4500-kw generating unit at station at Brownwood, Tex. Transmission and distribution lines, power substations and other operating facilities will be provided, entire project to cost about $48,000,000.

Va., Richmond—Virginia Electric & Power Co., Richmond, will continue its expansion program now under way during 1948, representing a total investment of about $25,000,000 in power plants, transmission lines, distribution system and other operating facilities. Work will include addition to generating station at Norfolk, Va., with installation of a new 40,000-kw turbine-generator, high-pressure boiler and accessories; new steam-electric station at Quantico, Va., with initial rating of 60,000-kw; addition to power plant at Chester, Va., to increase rating by 60,000-kw; and addition to plant at Bremo Bluff.

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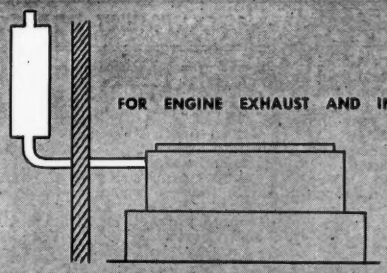

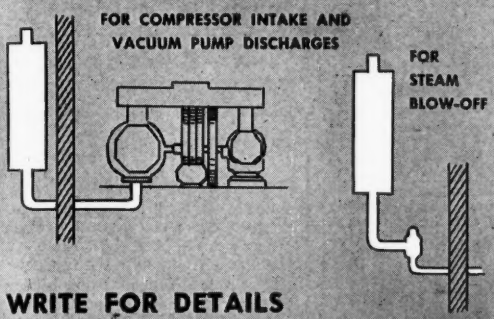

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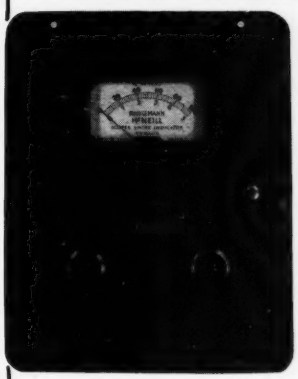

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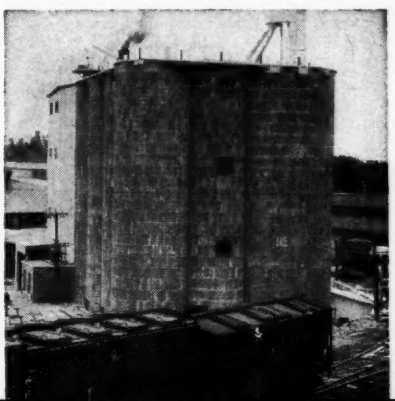

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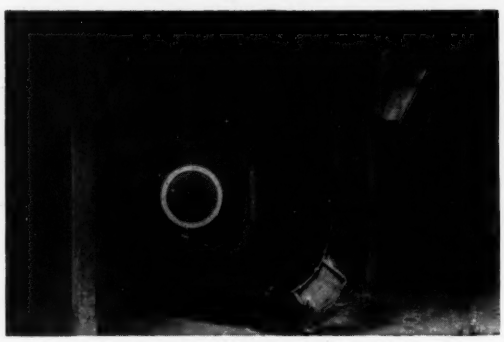

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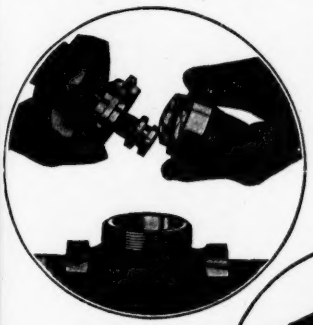

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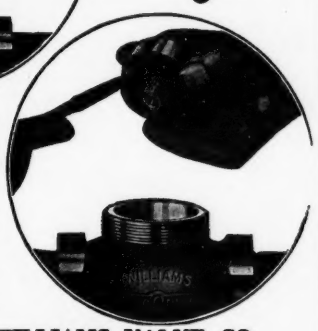

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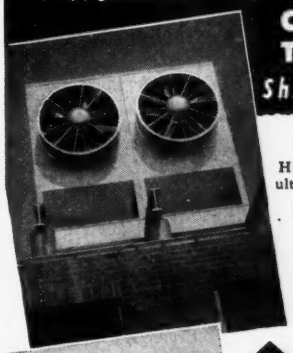

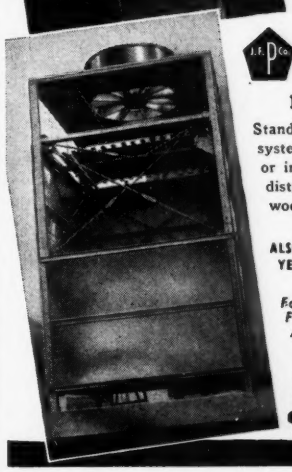

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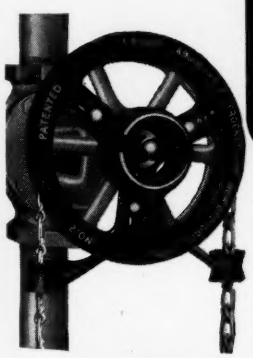

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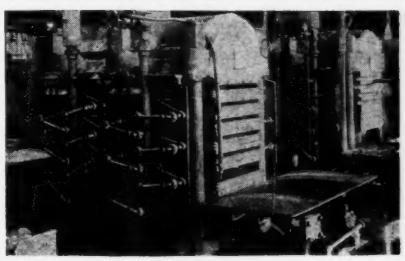

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Chapman Steel Valves are designed for pressures up to 1500 pounds per square inch . . . for temperatures up to 1000° F., or even higher, and as low as −160° F.

The Chapman Valve Manufacturing Co.

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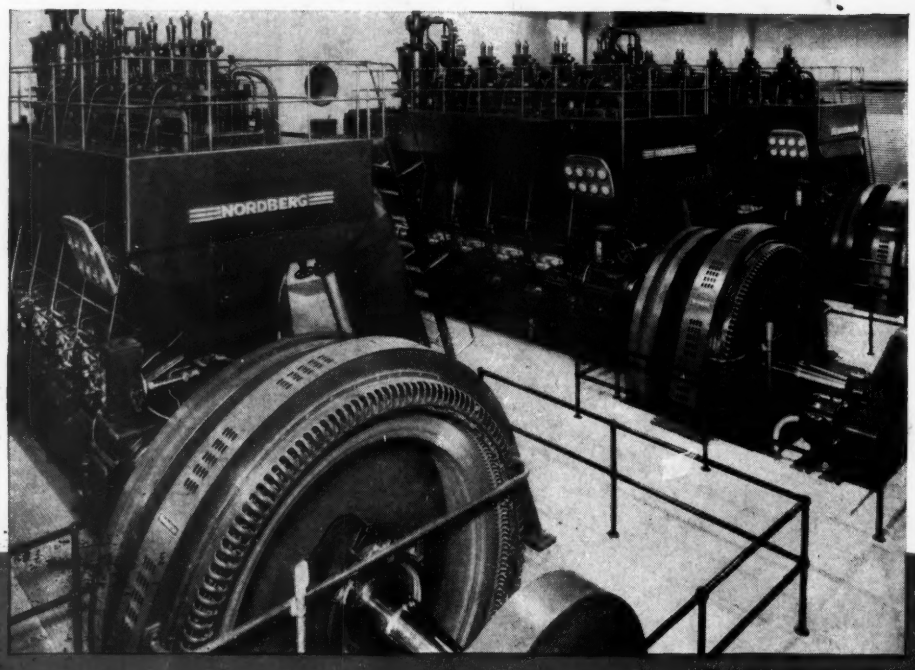

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2. *Low maintenance bills* because *Ursa Oils* assure freedom from sludge, varnish and carbon formations . . . prevent bearing corrosion . . . minimize wear. Your engines run longer between overhauls . . . parts replacements are fewer.

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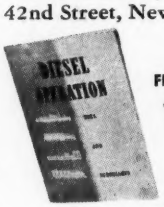

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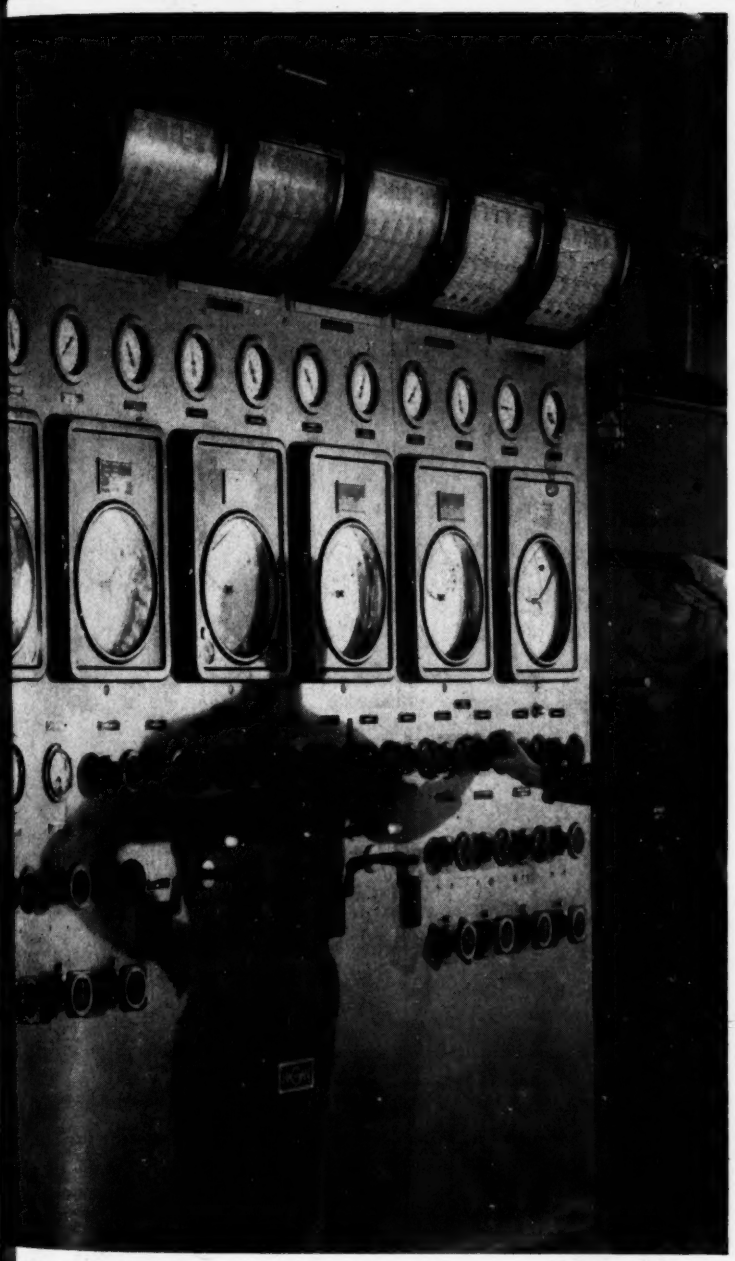

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COVER: BOILER CONTROL AND INSTRUMENT PANEL FOR LARGE CENTRAL STATION STEAM GENERATING UNIT, FIRED BY MULTIPLE-RETORT UNDERFEED STOKER, AND CAPABLE OF PRODUCING 300,000 LB OF STEAM PER HOUR NORMALLY, 400,000 LB PER HOUR ON PEAKS (WESTINGHOUSE PHOTO)

Magazine That Helps Men Responsible for Generation of Steam, Electricity and All Other Forms of Power Supply

That new, big modern

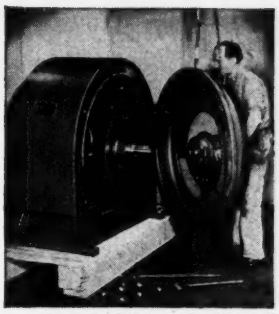
Elliott motor - make tak

Elliott

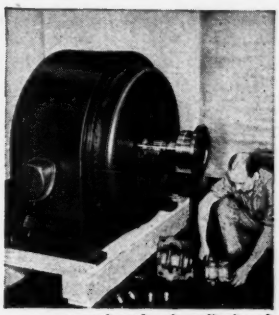
ke ake-downs quick and simple!

How to [illegible] a rotor

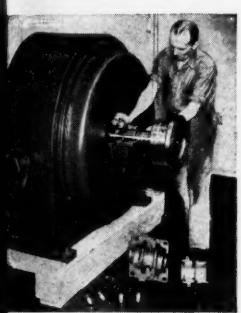
O NEED FOR SPLIT BRACKETS OR MOVING THE OTOR. On the free end of the motor (opposite the riven element) remove the bearing bracket cap crews, hook in the hoist, and start sliding complete racket, with bearing assembled, off the rotor shaft. That solid bracket, like the motor frame, is of steel, nd a good 30% lighter than a cast iron bracket of milar size. So . . .



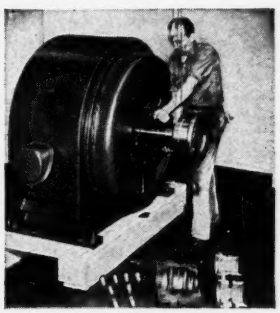
. . . it's a lot lighter to handle, and can be easily swung off and out of the way, leaving that end of the motor entirely open. That end of the rotor is then supported by the stator core. Next . . .



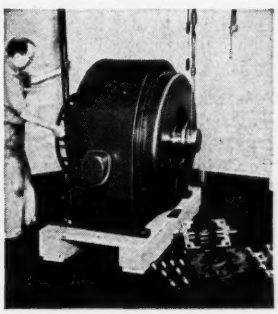
. . . start on the other (coupling) end of the motor, disconnect the coupling, take out the four cap screws and bolts holding the bearing cap, and also the top half of the split sleeve bearing. Then . . .



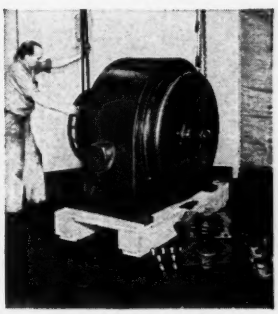
. . apply the hoist to the shaft, ting it a trifle to take the weight f the lower half of the bearing. ll the lower half around to the p of the shaft, lift it off, remove the p screws holding the bottom bear- g housing. Then . . .



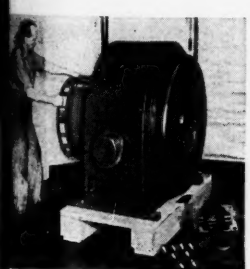
. . . bearing housing is rolled out, disclosing an opening in bracket large enough, in most cases, to permit coupling half to pass through without removing it from rotor. You don't have to touch the bearing bracket on this side. Saves a lot of trouble.



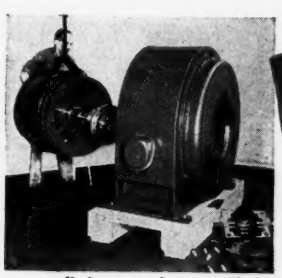
Then place a sling on the exposed shaft on the end of the motor from which bracket was removed. Push back outer part of coupling and place another sling. Give slings a bit of lift, and the rotor will then swing free. Start pulling it out. Next . . .



. . . transfer sling on coupling shaft after moving shaft enough to insert screw eyes for the hoist hooks, in the tapped holes usually provided in the coupling for pulling off coupling half. This permits of further withdrawal of the rotor. Finally . . .



. . transfer the rope sling to the enter of the rotor, so that it balnces in the sling. Swing the rotor ut still farther, unhook the sling rom the coupling end of the shaft . . .



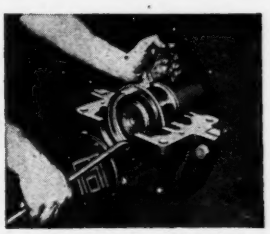
. . . pull the rotor clear out. That's all there is to it — and you've done the job without shifting the motor or taking off the coupling — hitting a new low in motor maintenance.

To reassemble, reverse the steps above except in replacing front bearing bracket assembly, rotate bracket 180 degrees to hold oil ring so it will clear shaft—push on and rotate bracket back to correct position.

Fabri-steel motors are built in 150 to 1000 hp, four to fourteen poles, drip-proof, splash-proof, forced-ventilated, pipe or base ventilated. Write for bulletin.

How to replace a bearing

Remove two cap screws, two bolts and two dowels and lift off the bearing cap. Pull out two small dowels and take off the upper half of the split sleeve bearing. Then . . .



. . . with a pry bar under the boss on the shaft end, raise the shaft enough to take the weight off the lower half of the bearing, roll it round to the top of the shaft and take it out from under the oil ring. An easy job.

L-702

C O M P A N Y

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